ARIZONA DEPARTMENT OF TRANSPORTATION

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COST/ BENEFIT AND RISK ASSESSMENT PROCEDURE FOR THE PRODUCT EVALUATION PROGRAM

Volume II
Product Evaluation Model
Reference Manual and User's Guide

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16. Abstract

The Product Evaluation Model (PEM) is designed to enable the Product Resource Investment Deployment and Evaluation program (PRIDE) of the Arizona Department of Transportation (ADOT) to determine the likelihood that a new product is a worthwhile investment from an economic point of view, namely that its benefits outweigh its costs. The model defines characteristics, (or "attributes"), associated with products, utilizes their appropriate units of measure (metrics) and translates these product characteristics into the estimated costs and benefits that occur over a user-defined analysis period. The main feature of the model is to measure the relative change in metrics that occurs with the use of a new product and to forecast the net present value (NPV), or the discounted, present day value of all benefits minus all costs, associated with this change. The resulting estimate of economic benefits allows transportation officials rank or choose among alternative products based on economic criteria.

This volume is the second in a series of two. Volume I is the final project report, containing information on the technical background, analytic approach and verification of PEM.

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METRIC (SI*) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	2.54	centimeters	cm
ft	feet	0.3048	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	6.452	centimeters squared	cm^2
ft^2	square feet	0.0929	meters squared	m^2
yd^2	square yards	0.836	meters squared	m^2
mi^2	square miles	2.59	kilometers squared	km^2
ac	acres	0.395	hectares	ha
		MASS (weight)		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams	Mg
		VOLUME		
fl oz	fluid ounces	29.57	millimeters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.0328	meters cubed	m^3
yd^3	cubic yards	0.765	meters cubed	m^3

Note: Volumes greater than 1000 L shall be shown in m^3.

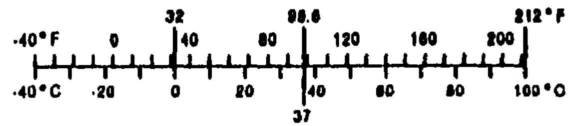
Symbol	When You Know	Multiply By	To Find	Symbol
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

These factors conform to the requirement of FHWA Order 5190.1A

*SI is the symbol for the International System of Measurements

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
yd	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	millimeters squared	0.0016	square inches	in^2
m^2	meters squared	10.764	square feet	ft^2
yd^2	kilometers squared	0.39	square miles	mi^2
ha	hectares (10,000 m^2)	2.53	acres	ac
		MASS (weight)		
g	grams	0.0353	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams (1000 kg)	1.103	short tons	T
		VOLUME		
mL	millimeters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	meters cubed	35.315	cubic feet	ft^3
m^3	meters cubed	1.308	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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1.0 INTRODUCTION

OVERVIEW

The Arizona Transportation Research Center's Cost-Benefit Product Evaluation Model (hereafter referred to as PEM) is designed to enable the Product Resource Investment Deployment and Evaluation program (PRIDE) to determine the likelihood that a new product is a worthwhile investment from an economic point of view, namely that its benefits outweigh its costs. The model defines characteristics, (or "attributes'), associated with products, utilizes their appropriate units of measure (metrics) and translates these product characteristics into the estimated costs and benefits that occur over a twenty-five year period[1]. The main feature of the model is to measure the relative change in metrics that occurs with the use of a new product and to forecast the net present value (NPV)[2] of the economic effects (benefits-costs) associated with this change. A flow chart describing this process is presented in Figure 1.1.

PEM addresses the uncertainty that often surrounds new product performance with a risk analysis process (RAP). This element of PEM allows the ATRC analyst to assign probability ranges around the product data inputs, based on the availability and the quality of information obtained from company representatives, product vendor sheets, laboratory testing, and ADOT personnel. The RAP element simulates the variability of factors that affect products in the real world and produces a probabilistic estimate of the economic costs and benefits associated with a new product.

The ATRC analyst can use PEM estimates of new product economic benefits for two basic objectives. At the basic level, PEM allows for a screening of a series of new products based on achieving a given threshold of net economic benefits. At a more expanded level, PEM can be used for real-time modelling during a RAP panel session where ADOT personnel, company representatives and industry experts (third-parties with significant professional or academic experience with the product under evaluation) are invited to investigate and deliberate the costs and benefits of a specific product. In either application, PEM provides the ATRC an objective, analytical tool to assess the economic merits of a new product, and to assist decision makers to determine whether the product should be tested or purchased and put into use by the Arizona Department of Transportation (ADOT).

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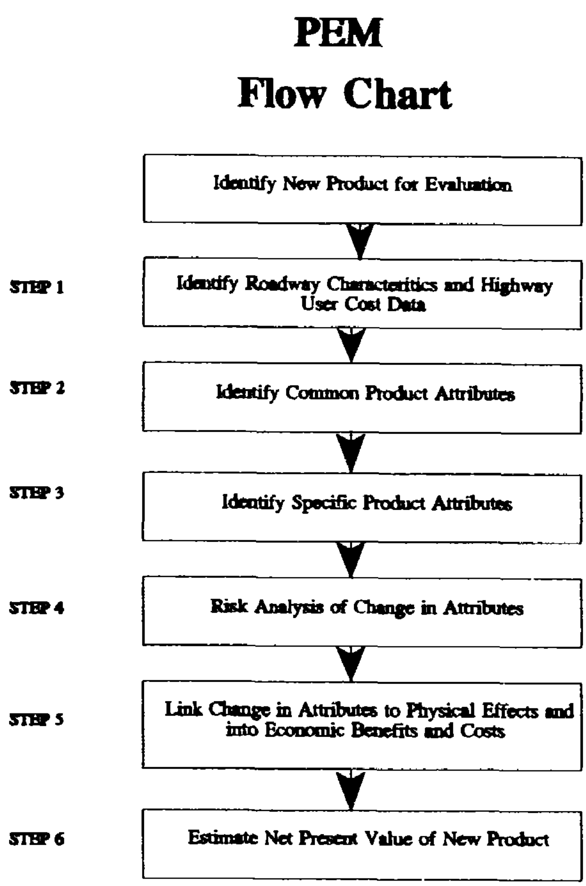
[1] A twenty five year time period is commonly used in the evaluation of transportation projects and investments.

[2] The Net Preset Value (NPV) of economic benefits is defined as the discounted, present day value of all benefits minus all costs.

Figure 1.1 Flow Chart of the PEM Process



FRAMEWORK FOR ANALYSIS

This section sets forth the analytical framework for PEM. Its two sections describe the principal analytical processes used by the model to estimate the probable range of net economic benefits associated with a new product. The first section outlines the cost-benefit approach to new products, while the second section discusses the risk analysis process and how it is incorporated in PEM. Taken together, these two processes form the foundation of PEM, and an understanding of these analytical tools is needed to interpret the model's output.

The Cost-Benefit Analytic Framework

The cost-benefit analytic framework serves as an objective tool to evaluate the economic merits of new products. The process measures all economic effects (costs and benefits) associated with the Base Case, or the current product in use, and compares these values with the New Product case, or the product under evaluation. The results of a cost-benefit analysis can then be used by the ATRC to better facilitate purchasing decisions among alternative products.

The standard techniques of cost-benefit analysis developed for assessing prospective transportation projects are used by PEM to evaluate the candidate products for evaluation by ATRC. The costs of transportation products and services are measured by the cost of real resources, or the equivalent value of these resources employed in an alternative use. These costs are determined through market prices, where such product markets exist, while the intangible costs associated with the product are estimated according to accepted statistical values such as: the value of time savings, life and injury (see the Technical Appendix). Aesthetic and environmental costs, in particular, require special attention in assigning monetary values to them. All costs are projected over the product life-cycle and are discounted to arrive at the NPV that can be directly compared with the NPV costs of the current product.

The PEM cost-benefit framework considers all reductions in costs as economic benefits. PEM explicitly accounts for eight categories of economic costs: safety, value of time savings, vehicle operating costs, disruption costs, productivity costs, capital expenditures, maintenance costs and liability costs. PEM indirectly accounts for environmental and aesthetic costs through a threshold analysis. A product whose attributes lead to reduced vehicle operating costs, and time savings, for example, produces user cost savings or economic benefits in these cost categories. These benefits (or costs) are forecasted over the entire analysis period and then discounted to reflect their present-day equivalent values. A new product may simultaneously produce both benefits and incur extra costs across different economic effect categories, but PEM is designed to sum these economic categories to produce a *net* benefit estimate of all economic categories. PEM's forecast of the NPV of economic benefit estimates can be used to make a direct comparison between products or to rank a series of products based on the relative NPV of economic benefits.

Data Requirements for Cost Benefit Analysis

PEM guides the analyst to enter the appropriate information to conduct the cost-benefit analysis. There are three types of input variables that the analyst must enter to run the model: roadway characteristics, highway user cost and ADOT policy data, and the metrics of common and specific attributes of new products. The first two types of input variables establish the background for the cost-benefit analysis while the third input variable group deals exclusively with the attributes of the new product. A short description of the types of input variables is presented below, while a detailed explanation of each variable in PEM is presented later in the User's Guide.

- ***Roadway Characteristics***
  These variables define the facility that will affect the area where the new products will be used or implemented.

- ***Highway User Cost and ADOT Policy Data***
  These are variables that reflect either policy-defined values for certain transportation-related inputs, such as the average value of time, or market prices for common transportation inputs, such as the price of fuel and tires, that will impact economic benefits.

- ***Metrics of Common and Specific Attributes of New Products***
  These are variables that measure the common and specific attributes of new products. They are typically obtained from vendor specification sheets, in-house laboratory testing or from other government agencies and associations.

The Risk Analysis Process

The purpose of risk analysis is to develop a range of outcomes and the probability of achieving them. The risk analysis process (RAP) component of PEM is designed to deal simultaneously with the risk of the multiple variables that affect product performance. PEM's RAP component operates on two functional levels: at the basic level, where the ATRC analyst inputs product data and self-generates a risk analysis simulation to forecast net economic benefits, and at the more advanced RAP level, where company representatives, industry experts and ADOT personnel are invited to deliberate the probability ranges surrounding central variables of the model and to comment on the resulting forecasts of economic benefits. This section briefly explains RAP and how it is used in PEM. A more detailed explanation of the risk analysis process is contained in the Reference Manual.

Variables and the Analysis of Risk

Many of the input values, or variables, used in PEM's cost-benefit analysis contain an element of uncertainty. To capture these real-world variations, a risk analysis, which develops a probability range for each variable, is introduced in PEM. The risk analysis *process* (RAP) employed in PEM refers to the *specific methodology* by which data relating to product attributes is subjected to a risk analysis. The RAP component of PEM adds a important dimension to the standard benefit-cost analysis since it accounts for the variation of values between variables and produces a range of potential economic benefits rather than a single net present value estimate.

A variable is assigned a range of uncertainty only if that uncertainty is a legitimate object of the analysis. For instance, uncertainty over the failure rate of a patching material should be accounted for in the analysis. However, the values associated with roadway characteristics, for example, should remain firm since they set the physical framework for the risk analysis. In addition to these variables, some of ADOT's transportation policies will be subject to uncertainty. The uncertainty in these variables, which reflect management judgment, should reflect uncertainty associated with their impacts and the uncertainty regarding which policy will be adopted.

The result of PEM's risk analysis is a forecast of the range of net economic benefits associated with the use of a new product, and the probability, or odds, that the product will produce a given level of net benefits. PEM's forecast of a product's net benefits allows ADOT planners and decision-makers to select the level of risk within which they are willing to plan and make commitments with regards to the testing or purchasing of new products.

PLAN OF THE MANUAL AND USER'S GUIDE

This reference manual and user's guide provides background information on the model and a step-by-step explanation of the process used to evaluate the economic effects (costs and benefits) of new products within a risk analysis framework. Section 2, the Reference Manual to PEM, provides the context for the PEM analysis, by specifying the types and sources of data needed run the model as well as a graphical and textual explanation of how PEM's variables interact to develop a forecast net economic benefits. Section 3, the User's Guide to PEM, provides a step-by-step account of how to operate PEM, from loading the software to editing a risk analysis scenario and running multiple simulations. Section 4 presents a PEM tutorial which uses actual product data to forecast the net benefits of six competing products. The final section of the manual, the Technical Appendix, contains information on the Highway User Cost Data used in the model.

2.0 REFERENCE MANUAL

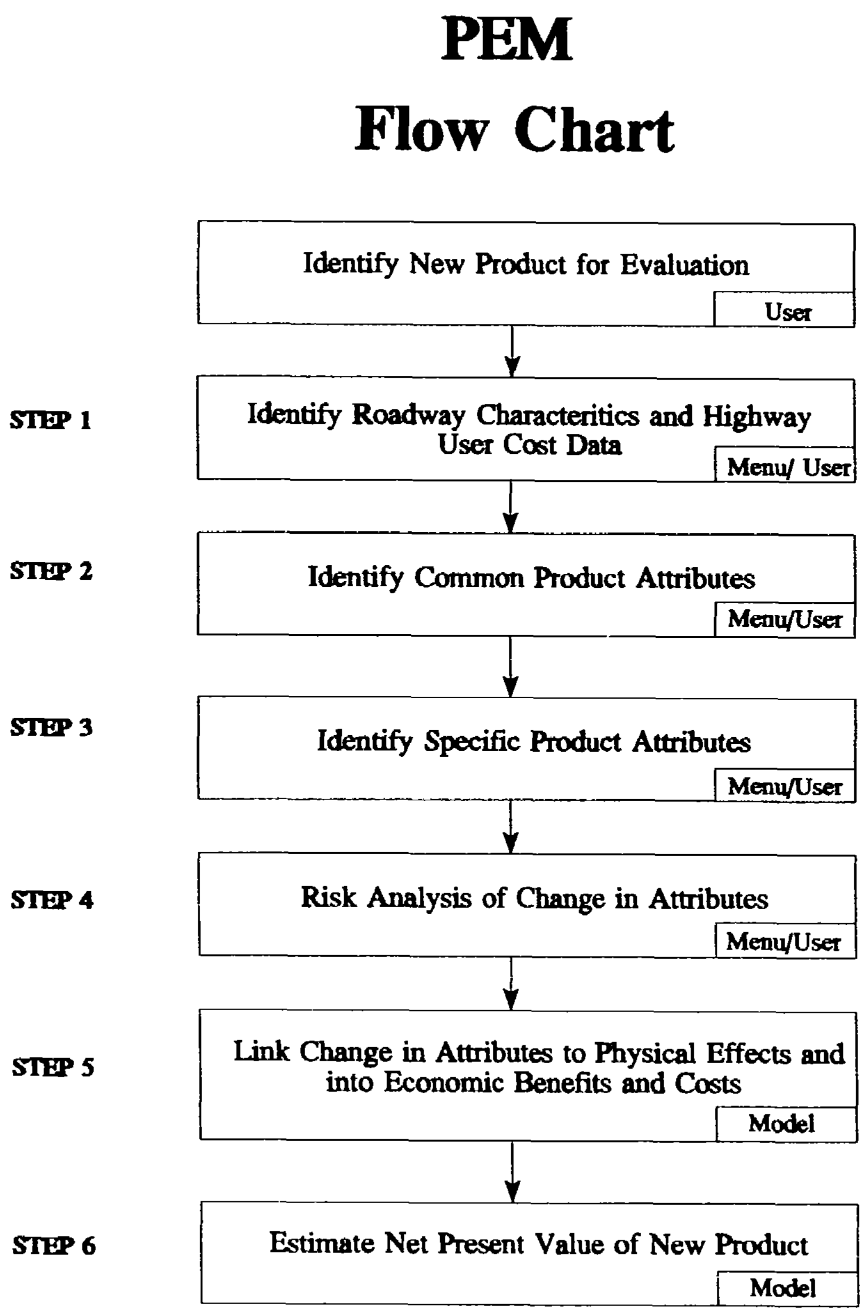
INTRODUCTION

PEM is designed to assist in the evaluation of new products in the ATRC's PRIDE program by providing a forecast of the net economic benefits associated with the use of each product. PEM requires the user to first input data on common and specific attributes, and then to make judgements concerning risk (either alone or with the aid of a RAP session) in order to assign probability ranges around the product data. PEM uses this information to forecast the probability range of net economic effects (benefits or costs) associated with the new product which can then be interpreted and used by the ATRC to aid in testing or purchasing recommendations.

The Reference Manual is designed to develop the context of the benefit-cost analysis. This section describes the process that the analyst should use in preparing the product information for PEM and in interpreting its forecasts. The section proceeds sequentially, starting with the steps that require the user to input data directly into the PEM software interface (see Figure 2.1). Following the description of the data input steps, the section focuses on the final steps of the PEM process and explains how the model uses product information to forecast economic costs and benefits in a risk analysis framework.

The reference manual assumes no prior risk analysis experience on the part of the user, nor does it require a background in economics to understand the benefit and cost

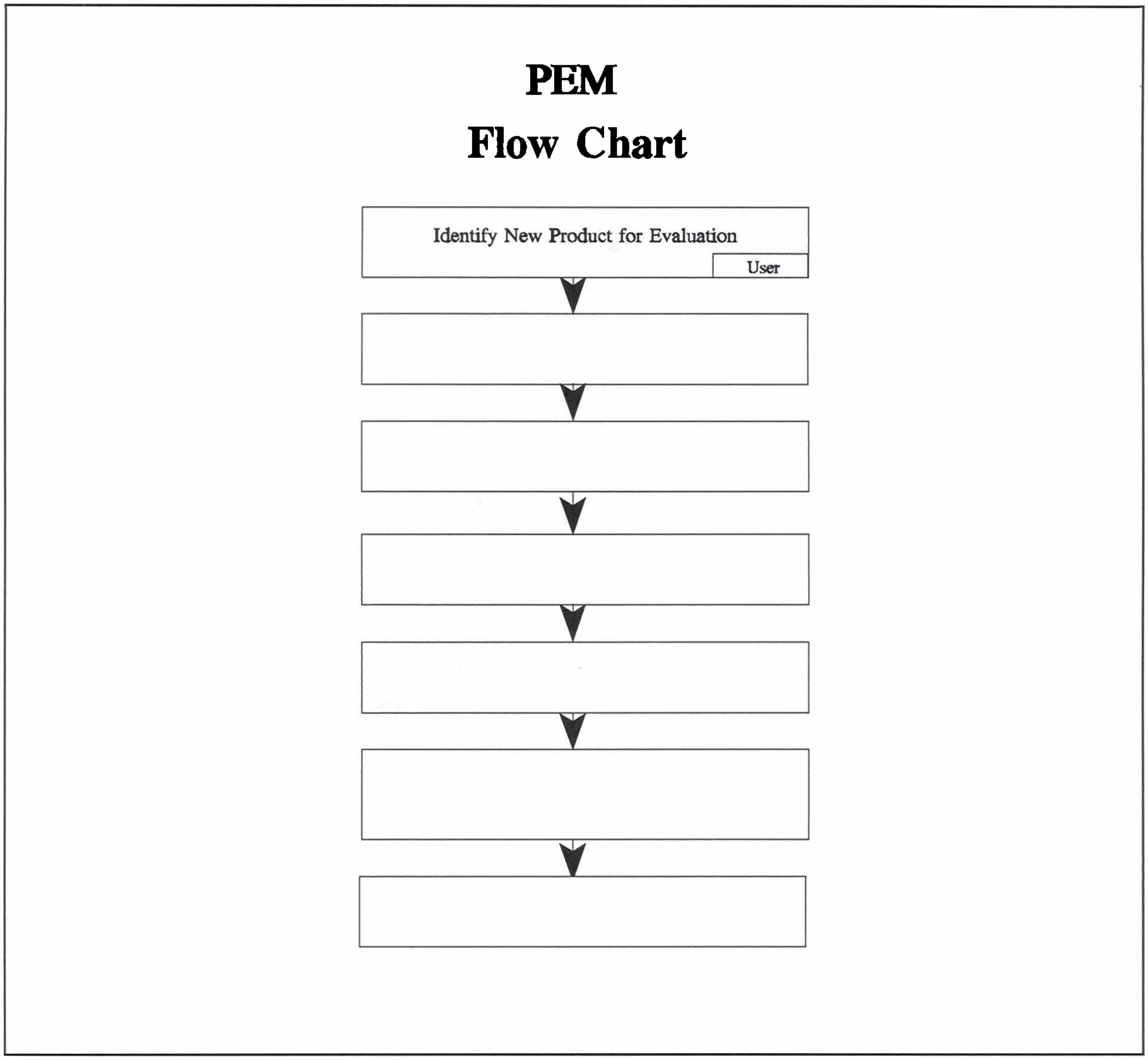
Figure 2.1: Flow Chart of the Six Steps of the PEM Process



forecasts generated by the model. Its main objective is to provide suggestions and techniques to obtain the necessary data for PEM, explain how that data is used by the model, and to interpret PEM's forecasts of economic benefits and costs. Wherever possible, graphics and structure and logic diagrams are used to illustrate the links between user inputs and model outputs.

Throughout the section, the PEM flow-chart motif is used to divide the sequential steps that comprise the PEM process. Each rectangular box represents a basic step in the modelling process, with the smaller box on the lower right-hand side of each box indicating the primary responsibilities for each step. "User" refers to the independent responsibility of the ATRC analyst to make a decision or action. "Menu/User" refers to the responsibility of the user to input product data according to the model's menu-driven, input screens. "Model" refers to PEM's independent calculation of economic benefits and costs based on the previously provided product data.

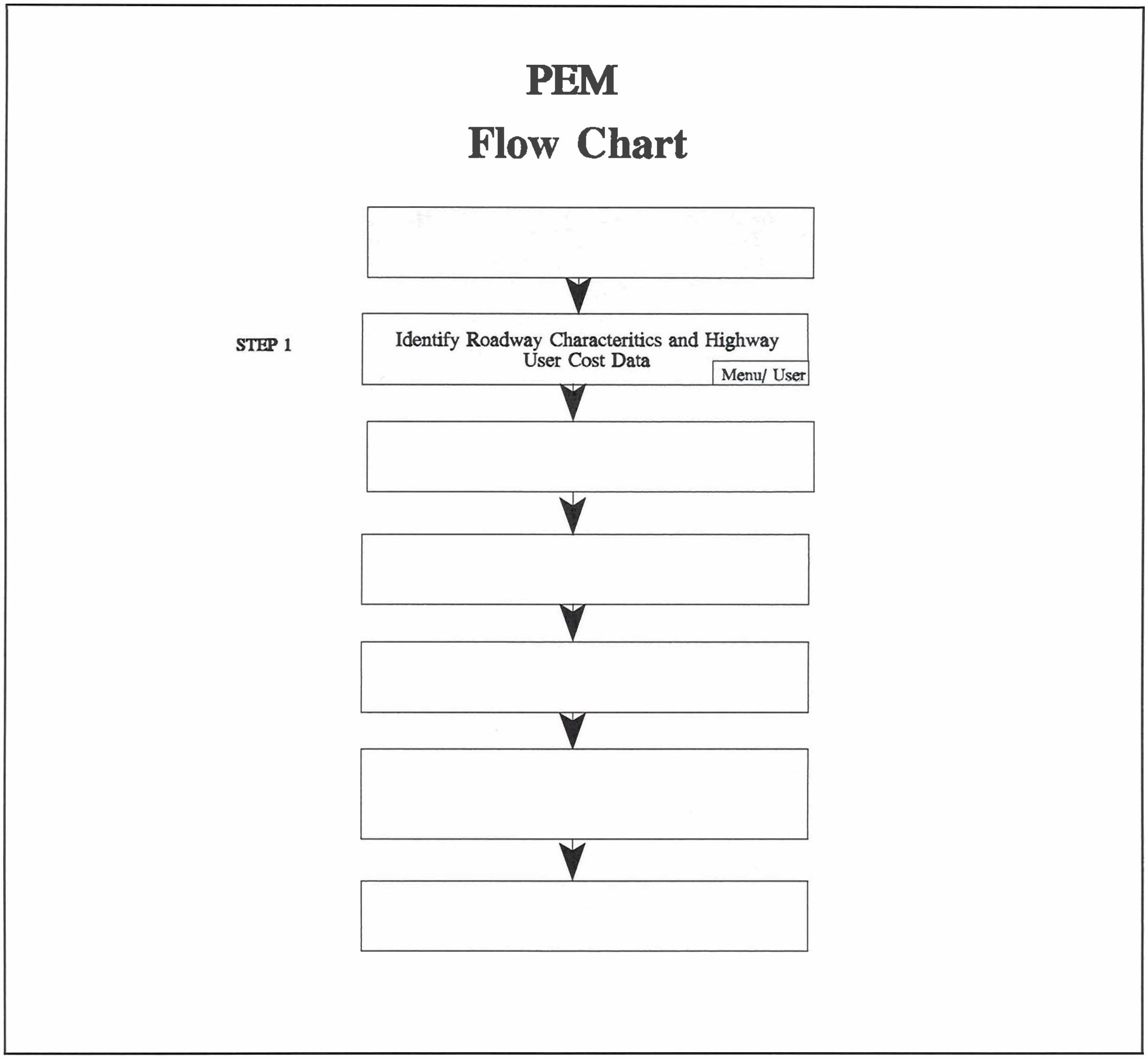
IDENTIFICATION OF NEW PRODUCT FOR EVALUATION



Before the PEM process can begin, the ATRC must identify a new product for evaluation. This is largely an internal ADOT process dependent on a variety of decision-making criteria. Typically, the process involves reacting to one of the numerous product approval applications that are received annually by ADOT.

Prior to using PEM, the ATRC (or the analyst) should decide how they intend to use PEM forecast of net economic benefits. The distinction between evaluating a product for further testing by ADOT and purchasing the product outright for immediate use implies different standards for judging the model's forecast. A proto-type product with limited field experience, for example, might have to demonstrate a relatively high probability of achieving a level of net economic benefits before it should be tested further by ADOT. Conversely, a new variation of a product already in use by ADOT, might be held to a less stringent standard, since the risk associated with the product performance is known and accepted, and any improvements would be made at the margin.

PEM STEP 1



In step 1 of PEM, the user is asked to identify the roadway characteristics and highway user cost and ADOT policy data that will be used in the cost benefit analysis. This data is used to set the physical framework and default user cost values for the analysis (for a complete listing of the variables in each category, refer to the User's Guide). It is important to carefully prepare the inputs for these variables, since inaccurate entries at this stage can significantly impact the model's benefit forecasts. The following two sections describe the data needed for this step and the potential sources for obtaining it.

Roadway Characteristics

Roadway characteristics define the facility where the new products will be used or implemented. The analyst should know, for example, whether a particular product is planned to be used on a four-lane highway or on smaller, rural roads. This basic distinction affects the potential traffic disruption effects, for example, since they are proportionately tied to the size of roadway facilities as well as to the kilometer length of the highway and Average Annual Daily Traffic (AADT).

Sources of Data

The principal sources for obtaining roadway characteristics data are from ADOT personnel. ADOT District Engineers and maintenance crews are familiar with the types of roads and conditions where most products are used and they can usually supply ample anecdotal and factual information for several inputs in this section. For variables dealing with Highway Design or Facility Type, ADOT Engineering Supervisors are a source of information, as well as the personnel from the contracting divisions that draft specifications for ADOT construction contracts.

Highway User Cost and ADOT Policy Data

Highway User Cost and ADOT Policy Data reflects either policy-defined values for certain transportation-related inputs, such as the average value of time, or market prices for common transportation inputs, such as the price of fuel and tires, that will impact economic benefits. Once these values are agreed upon, they remain constant for the PEM analysis. A complete listing of the Highway User Cost Variables is presented in the User's Guide, as well as the default values, which are contained in the Technical Appendix.

Sources of Data

Values for the Highway User Cost Data come from the body of federal and state transportation research. The cost figures, such as fuel costs, the value of time, and various accident costs were compiled from national data and through an extensive research project into highway user costs completed for the National Cooperative Highway Research Program by Hickling[3]. The physical effects, such as the maximum impact of pavement conditions on speed and accident rates are from Hickling experience.

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3 NCHRP Project 2-18: Research Strategies for Improving Highway User Cost-Estimating Methodologies (1993)

The model equations, which result in user cost estimates in the areas of speed (value of time), safety, and vehicle operating costs, are derived from separate sources. The safety equations are based on data tables incorporated in the Highway Economic Requirements System (HERS)[4]. The vehicle operating cost equations are based on the Technical Memorandum to NCHRP project 7-12, Microcomputer Evaluation of Highway User Benefits, by the Texas Transportation Institute (Technical Memorandum)[5]. The equations are based on empirical relationships derived by Thawat Watanada et. al[6]. during the late 1970's and early 1980's.

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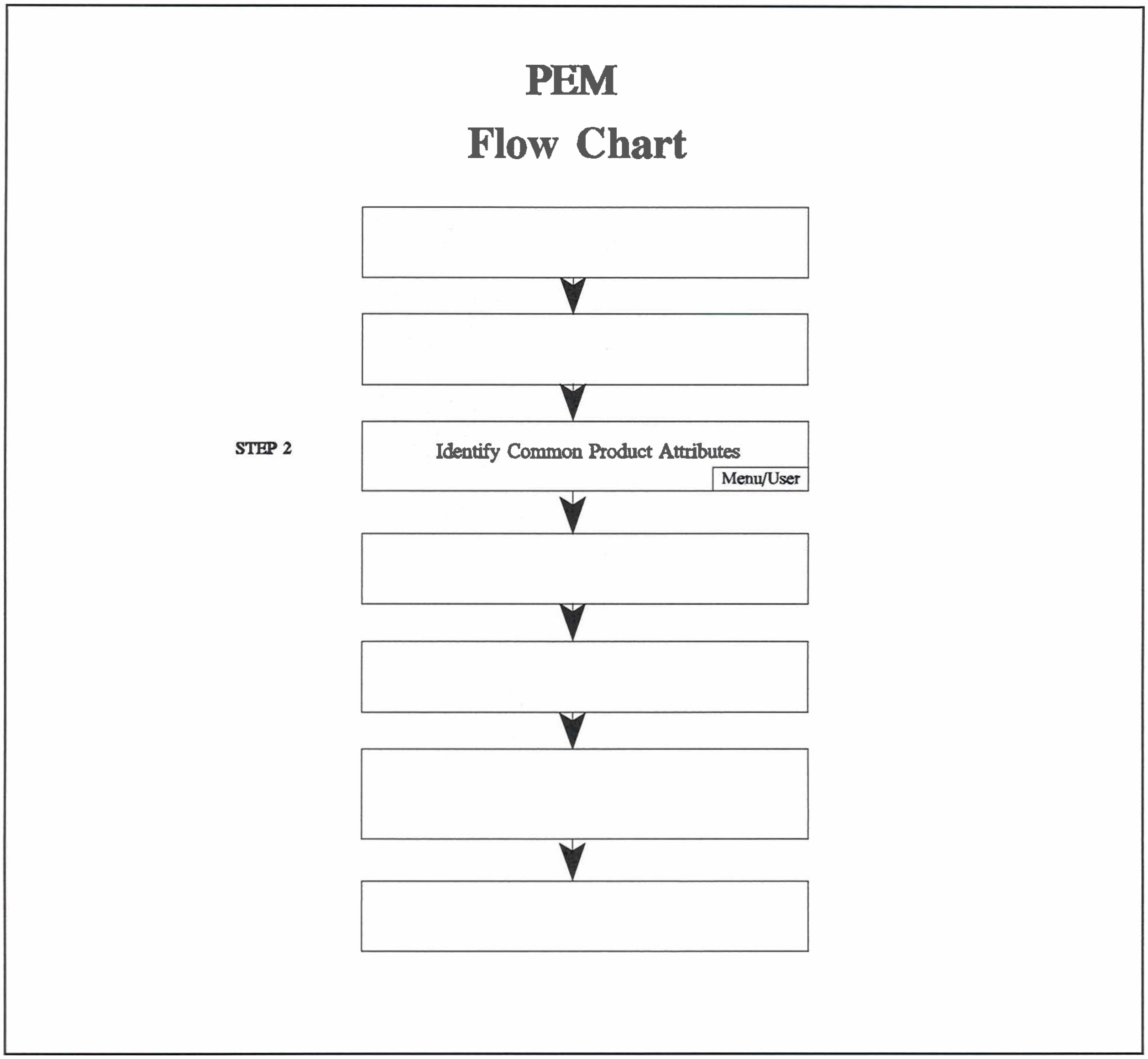
[4] Jack Faucett Associates, The Highway Economic Requirements System (HERS) Technical Report. prepared for the U.S. Department of Transportation, Federal Highway Administration, Washington, D.C., June, 1991.

[5] Texas Transportation Institute, Technical Memorandum on Tasks 1 and 2 of NCHRP Project 7-12 "Microcomputer Evaluation of Highway User Benefits," 1990.

[6] Watanada, Thawat et al. Vehicle Speeds and Operating Costs: Models for Road Planning and Management. (Washington, D.C.: The World Bank) 1987.

PEM STEP 2: COMMON PRODUCT ATTRIBUTES



In step 2 of PEM, the user identifies common product attributes which refer to the standard qualities or features of a product that are used in the cost-benefit analysis. The main task of the analyst, at this point in the PEM process, is to develop a Base Case, or the set of values for common product attributes that are associated with the current product. Once these values are established, the analyst can then use PEM to compare the set of values of common product attributes associated with the *new* product to determine whether it produces net economic benefits.

PEM distinguishes between those attributes which are "common" to all products, such as unit cost, useful economic life, and labor and equipment costs and "specific," those attributes which are particular to certain products, which is presented in the next section. Examples of common product attributes used in PEM are listed below (an explanation of each product attribute is presented in the User's Guide):

- Useful Economic Product Life;
- Inventory and Carrying Costs;
- Disposal and Salvage Costs;
- Testing and Evaluation Costs; and
- Failure Rate Path (the pattern of product failures over time).

Sources of Data, Base Case

Data for the Base Case can normally be obtained from ADOT and other sources. The following sections briefly explain the types of data that is available from each source.

ADOT Sources . Several sources within ADOT provide practical information on product use and maintenance which can be used to develop the Base Case. ADOT divisions that either actively plan or budget routine maintenance and construction procedures are one source of useful Base Case product cost information, as are the implementing divisions, such as district engineers, that have had direct experience with specific products or procedures. The following is a sample list of the ADOT sources that maintain the type of data needed to run PEM:

ADOT Maintenance Group

The division's PECOS II Maintenance Management System provides basic historical cost data on material, labor, equipment, installed inventory, and productivity according to pre-defined maintenance categories. This database system can provide median common product attribute estimates for the Base Case. Considering the specific product and other performance information, the analyst can then assign probability ranges around these estimates to develop the probability distributions for use in PEM's RAP component.

The following table illustrates the common product attribute data contained in the PECOS II Maintenance Management System:

Table 2.1: Common Product Attributes; Maintenance Activity 115, Spall Repair PCC Pavement

Data Category	Value	Units
Work Quantity	189.4	Cubic ft.
Inventory	774.0	12 ft. lane miles
Quantity STD	.2	Cu. ft./lane mile
Labor Hours	1702.5	Labor hour
Productivity	.11	Cu. ft/labor hour
Total Cost	$71,792.54	Dollars
Unit Cost	$379.05	Dollars/labor hour

Using the information in the Table 2.1, the analyst develops the Base Case common product attributes by adding probability ranges to each of the variables used in PEM. According to the table, labor productivity is .11 cu.ft. per labor hour across all ADOT maintenance organizations. The ATRC analyst, however, based on research and interviews with ADOT engineers, may feel that labor productivity for this activity and the current product could reach .2 and will seldom drop below .10 cu. ft. per labor hour. PEM inputs for Base Case product labor productivity, therefore, would be .2 for 10% upper range .11 for median estimate, and .10 for the lower 10% range (this process is explained further in the section 2.6).

ADOT Office of Risk Management

To determine the Liability Risks associated with a product, the analyst should contact the ADOT Office of Risk Management. Generally, the manager of this office will be able to provide some information on the liability costs associated with a given product, even through product liability cases tend to be less frequent than design or maintenance liability cases. For those products that do have a history of liability costs, such as concrete patching materials, the analyst will be able to develop a Base Case liability cost scenario. The following table summarizes the Base Case liability variables associated with a concrete patching material:

Table 2.2: Common Product Attributes; Liability Variables Associated with Concrete Patching Materials

Liability Variable	Value	Units
Number of Claims per 100 Failures	10	Claims
Percent of Claims Settled	30-40	Percent
Percent of Claims Not Pursued	60	Percent
Average Settlement Costs	500-750	$ per Settlement plus Admin. Costs
Court Costs	$15,000	$ per Trial plus Admin. Costs

Based on Table 2.2, the Base Case liability costs for concrete patching materials are likely to be small on an annual basis, but may be considerable over the analysis period used in PEM. The percentage of product failures is the most difficult variable to estimate, since accurate data on product failures is difficult to obtain. In this example, only 10 percent of product failures result in claims against ADOT. Of these claims, 30 to 40 percent result in settlement, with the majority being claims not pursued, either because the claim was denied or dropped. For those claims that result in court cases, which is imputed by PEM, ADOT can incur substantial costs of up to $15,000 in this example.

Other Sources. Other, non-ADOT, sources of information are effective for developing the Base Case set of common product attribute variables. The Transportation Research Information Services (TRIS) section of the Transportation Research Board (TRB) of the National Academy of Sciences maintains an extensive database of all ongoing domestic and foreign transportation research. Current and past studies of transportation-related products and/or their use and application are listed from several state and federal research programs. Studies such as, Implementation Strategies for Sign Retroreflectivity Standards, NCHRP Report 346, provide product information on several types of retro-reflective sign sheeting, including average product cost, units per mile (per kilometer) of rural and urban signs and typical maintenance costs. Data from such credible sources can readily be used to supplement or substitute the Base Case set of common product attributes variables.

Sources of Data, New Product

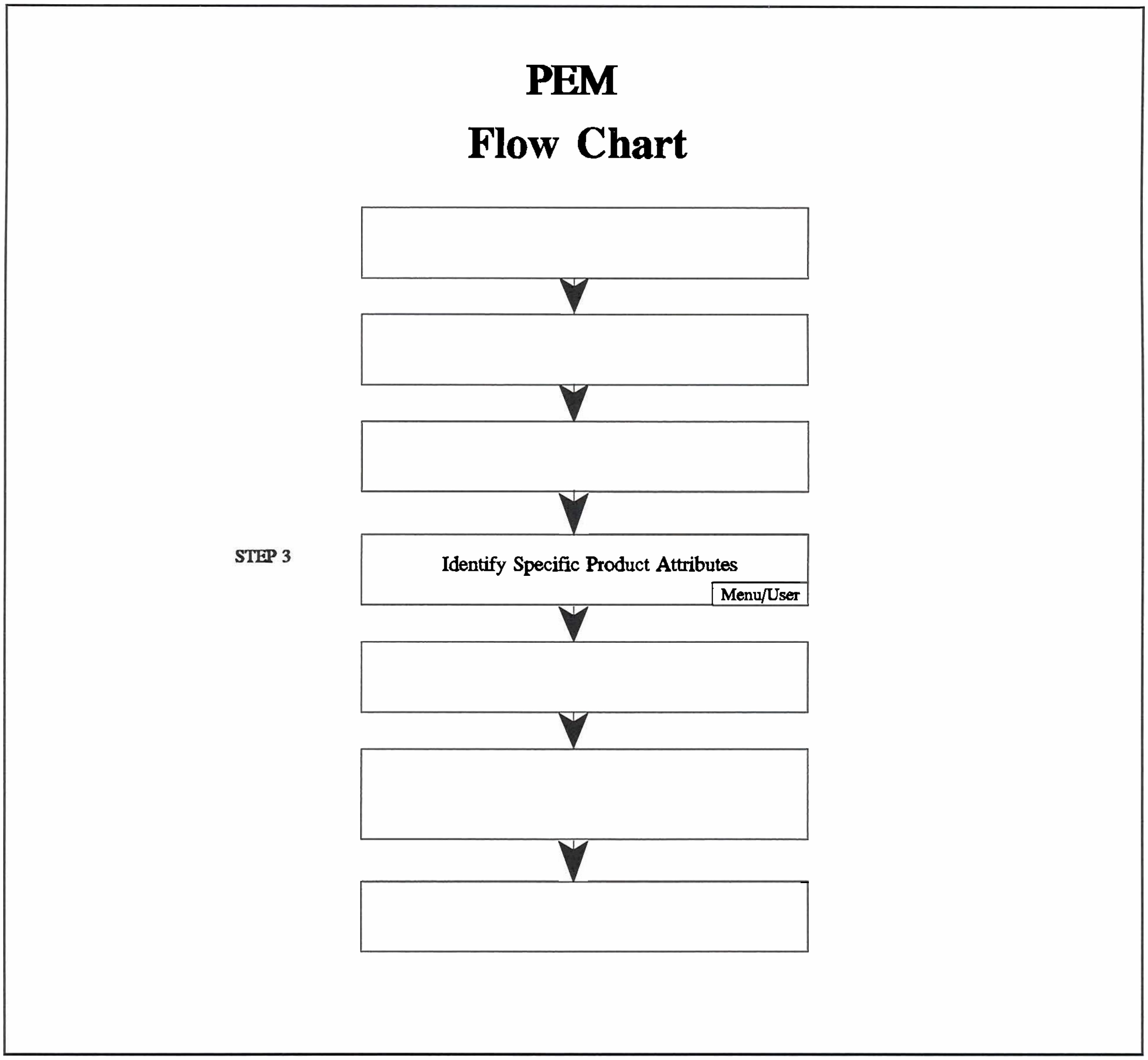
To evaluate a **new** product with PEM, the analyst must obtain information corresponding to the common product attributes developed for the Base Case product. Although vendor sheets occasionally specify the typical labor and equipment costs associated with a product, these estimates may be based on ideal conditions and therefore may exaggerate the values. Nevertheless, these values can be used as a basis for the initial median estimates, around which probability ranges can be developed. When utilizing vendor data the probability range around the median estimate is likely to be larger for this reason (a more detailed explanation of assigning probability ranges is explained in section 2.6). The following sections describe the principal sources for new product information:

Product Vendor Sheets. As explained in the earlier, product vendor sheets and official company submissions are the primary source of general product information for PEM's product attributes data fields. Following the ATRC's "Checklist for New Proposals" (see Technical Appendix), the manufacturer must provide product information ranging from independent lab tests to the manufacturers' cost sharing in ADOT product testing and evaluation. These submissions contain the basic information, such as unit cost, equipment requirements (costs), and productivity estimates that allows the ATRC analyst to begin the cost-benefit analysis using PEM. In some cases, these vendor sheets contain extra information that can readily be used by PEM, such as product life cycle estimates and direct comparisons with competing products. Local contractors and product representatives are also an obvious source to solicit common product attribute information.

Other Sources. State and federal transportation agencies routinely conduct new product evaluations. State DOTs typically obtain technical information and product specifications from in-house testing, reliance on vendor presentations and demonstrations, and reference to new product information from other State DOTs and industry publications. Information exchange is also facilitated by the American Association of State Highway Transportation Officials (AASHTO) in cooperation with the Federal Highway Administration (FHWA) through a computer database of new product information entitled the Special Product Evaluation List (SPEL).

The Strategic Highway Research Program (SHRP) is also an important source for new product information. Created in 1987 to improve the performance and durability of U.S. roadways, the SHRP program, with support from the Federal government, State DOTs, AASHTO and the Transportation Research Board (TRB), investigated 130 new highway products in four areas: highway operations, concrete and structures, asphalt and long term pavement performance. The SHRP report entitled, Innovative Materials Development and Testing; Volume 5; Partial Depth Spall Repair; (SHRP H-356), for instance, contains extensive information on brand-name materials and optimal application procedures for the partial spall repair of Portland Concrete that can be used in PEM.

PEM STEP 3: SPECIFIC PRODUCT ATTRIBUTES



In step 3 of PEM, the user identifies the specific product attributes associated with a given product. Like common product attributes, they refer the qualities or characteristics that are used in the cost-benefit analysis, but in this case, they refer to the unique properties of a product that are not necessarily found in all products. For example, pavement materials share many common product attributes, such as unit price and product life cycle, but they also have specific attributes that affect the smoothness of the pavement, a trait that can be mapped into user benefits, such as Vehicle Operating Costs. The important point to note is that these attributes are *not common to all products.*

PEM is equipped to deal with certain specific common attributes. While it is not necessary to input data for each of these categories, they can bring a important additional level of detail to PEM's cost-benefit analysis.

Some of the specific product attributes contained in PEM include:

- PSI of Pavement with New Product;
- Expected Pavement Life with New Product;
- Resurfacing Costs with New Product;
- Percent Administrative Improvement Realized;
- Percent Reduction in Fatal Accidents with New Product; and
- Percent Improvement in Speed/Flow with New Product.

The specific product attributes outlined above apply to two basic categories of products. The first three specific attributes apply to those products that affect pavement condition, which as described earlier, can lead to benefits in Vehicle Operating Costs, as well as the Value of Time and Safety. The last four specific attributes refer products that in some manner affect Productivity, Safety or the Value of Time. These attributes are more subjective than the first set, and can consist of multiple factors that together impact the benefit category (A full description of each specific product attribute appears in the User's Guide).

Sources of Data, Base Case

ADOT Sources. As with common product attributes, sources within ADOT can provide practical information on product use and maintenance which can be used to develop the Base Case. ADOT divisions that deal with pavement maintenance and construction procedures are one source of useful Base Case information, as are the implementing divisions, such as district engineers, that have had direct experience with specific products or procedures.

Sources of Data, New Product

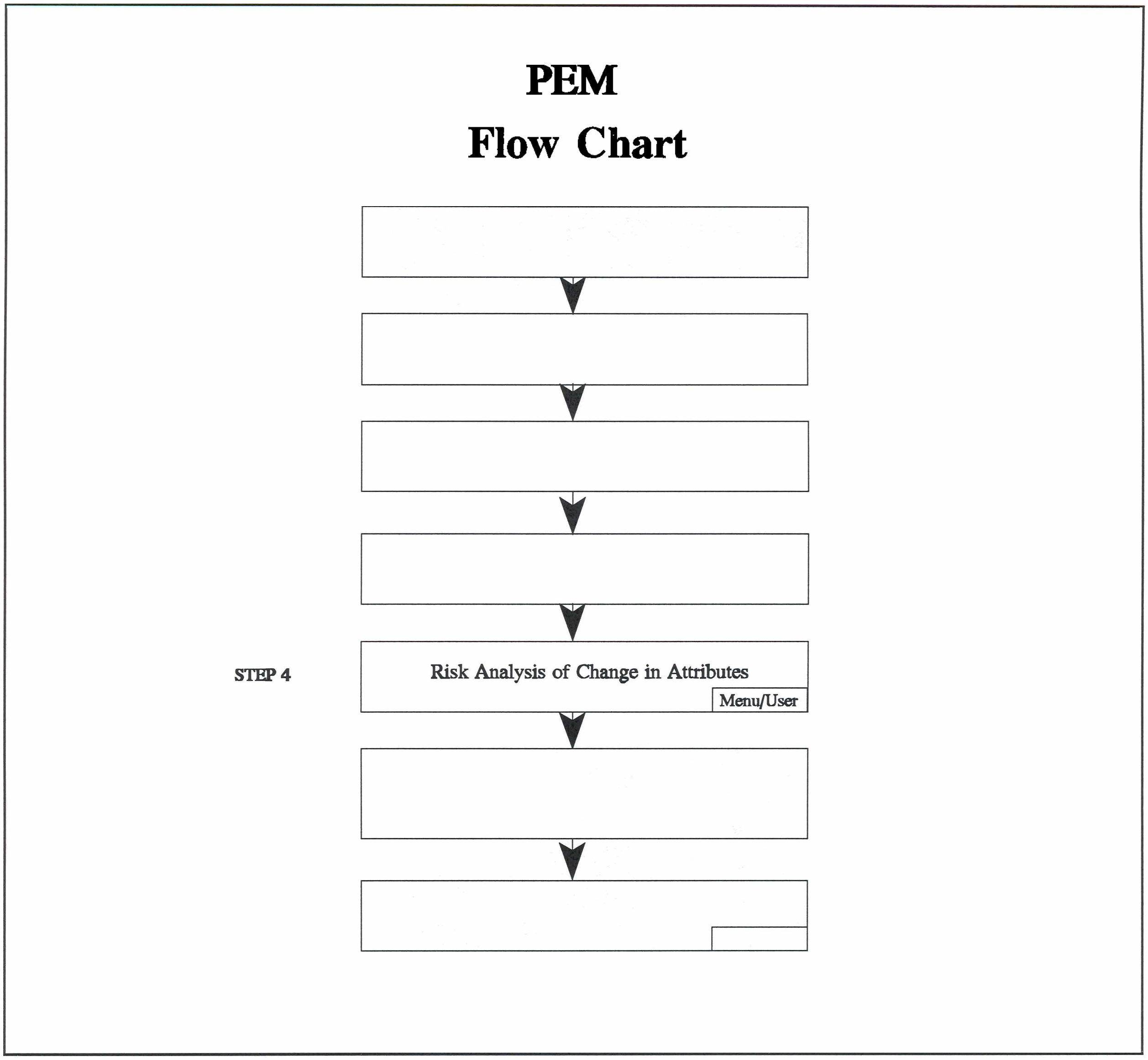
There are generally two sources for obtaining information on the specific product attributes of new products.

Product Vendor Sheets. As described with common product attributes, product vendor sheets usually contain basic information on product characteristics that can be used in PEM. With regards to specific attributes, some manufacturers may tout a certain advantage of their product over others. This documented information can be brought into PEM through the specific attribute variables, such as reduction in accident incident rates. Often, however, it is useful to check the source/study that is behind the manufacturer's claim.

Other Sources. State and federal transportation agencies routinely conduct product evaluations which contain information that can be used to support values for specific product variables. As in the example above, a manufacturer may claim that his product has certain impact on accident rates which may or may not be confirmed by current studies.

In the event that a value can not be confirmed or supported by any current study, the uncertainty surrounding that value will be greatly increased. This heightened uncertainty will be reflected in the probability range assigned to that value by the user or the RAP panel. This increased uncertainty will reduce the impact of the variable in the model. A more detailed explanation of this process is contained in section 2.6. It is with these types of variables that RAP panels, consisting of experts in the product field, are most useful in determining what the value should be and the probability to attach to it. The RAP panel in this case, would provide the confirmation and support for the estimate that could not be provided by current studies.

PEM STEP 4



In PEM Step 4, the user assesses the degree to which a new product's attributes will lead to a measurable change in metrics and forecasts the potential variation of that change. To deal with the uncertainty surrounding new product performance, the analyst places probability ranges around each variable subject to real-world fluctuation based on both objective and subjective data sources, which leads to a more accurate forecast of the potential economic benefits stemming from a new product. This section presents the background on the Risk Analysis Process (RAP) and how it is applied in the Cost-Benefit framework of PEM.

Risk Analysis and the Benefit-Cost Model

The goal of a cost-benefit analysis is to determine the effect of a change (or changes) in the resource allocation associated with the introduction of a new product or process. A new product which reduces maintenance costs (a maintenance savings) through its durability, for example, produces an economic benefit in the PEM analysis, and is preferred over the existing resource allocation. The critical analytical role in this step is determining the actual change in physical effects that will occur with each new product attribute as well as the timing for these changes. Since product performance is often unpredictable, a risk analysis of the central variables in the cost-benefit framework adds an important, real-world dimension to the analysis.

The RAP component of PEM includes two variations. Variation one is the basic level screening process in which the ATRC analyst inputs median estimates of common and specific product attributes and assigns probability ranges. A risk analysis simulation is then conducted on one or several products to determine the relative NPV of the economic benefits associated with each product. Variation two, the expanded version of RAP, involves the same process as variation one, but adds a step in which the probability ranges around product data variables are open to discussion at a RAP panel session. The steps involved in both variations are outlined in the following sections.

The Basic RAP, Variation One

Variation one of PEM's RAP component allows the **analyst** to attach probability functions to the uncertain estimates associated with the Base Case and ne product common product attributes. This process addresses the fact that the further into the future product performance is forecast, the more uncertainty there is and the greater the risk becomes of producing forecasts that deviate from actual outcomes. Projections in PEM, therefore, need to be made with a range of input values to allow for this uncertainty and for the probability that alternative economic, demographic, technological and environmental conditions may prevail that affect the set of common product attribute variables.

The ATRC analyst collects data for the RAP component of PEM starting with the steps 2 and 3 of the PEM process. Special data sheets, created by the ATRC and similar to the one pictured in Figure 2.2, are used to record the common and specific product attribute estimates, which can vary according the quality of the product data, outside testing information, ADOT anecdotal experience, or other pertinent factors. The analyst should combine this objective and subjective data into data sheets for each variable. In Figure 2.2, a sample data sheet provides space for an initial median estimate in the first column, and the second and third columns define a range which represents "an 80 percent confidence interval" -- the range within which we can be 80 percent confident of forecasting the product performance. If the analysts is very uncertain of the forecast of product performance, a wider probability range is used (and vice versa). This process ensures that all risks are properly reflected in the PEM forecasting process.

Figure 2.2: Sample of a Data Sheet for the Risk Analysis Process

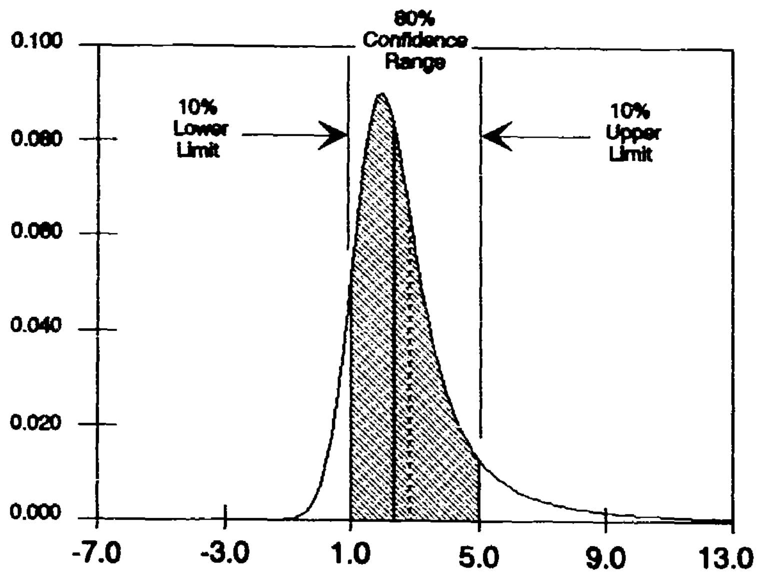
Annual Training and Equipment Costs
(Annual $)

Product	Median Estimate	10 % Lower Limit (%)	10 % Upper Limit (%)
New Product	$3,800	$3,420	$4,180
Current Product	$4,000	$3,800	$4,500

Probability ranges need not be normal or symmetrical -- that is, there is no need to assume the bell shaped normal probability curve. The bell curve assumes an equal likelihood of being too low and being too high in forecasting a particular value. It might well be, for example, that additional training and equipment costs, as presented in Figure 2.2, are more likely to exceed the median estimate than to not attain it. The RAP process places no restrictions on the degree of "skew" in the specified ranges and thus maximizes the extent to which the Risk Analysis reflects reality.

Although the computer program will transform all ranges into formal "probability density functions", they do not have to be determined or presented in either mathematical or graphical form. All that is required is the entry of upper and lower limits of an 80 percent confidence interval in the Data Sheets. The risk analysis software will then use numerical analysis to translate these entries into a uniquely defined statistical probability distribution automatically (see Figure 2.3). This liberates the non-statistician from the need to appreciate the abstract statistical depiction of probability and thus enables administrators,

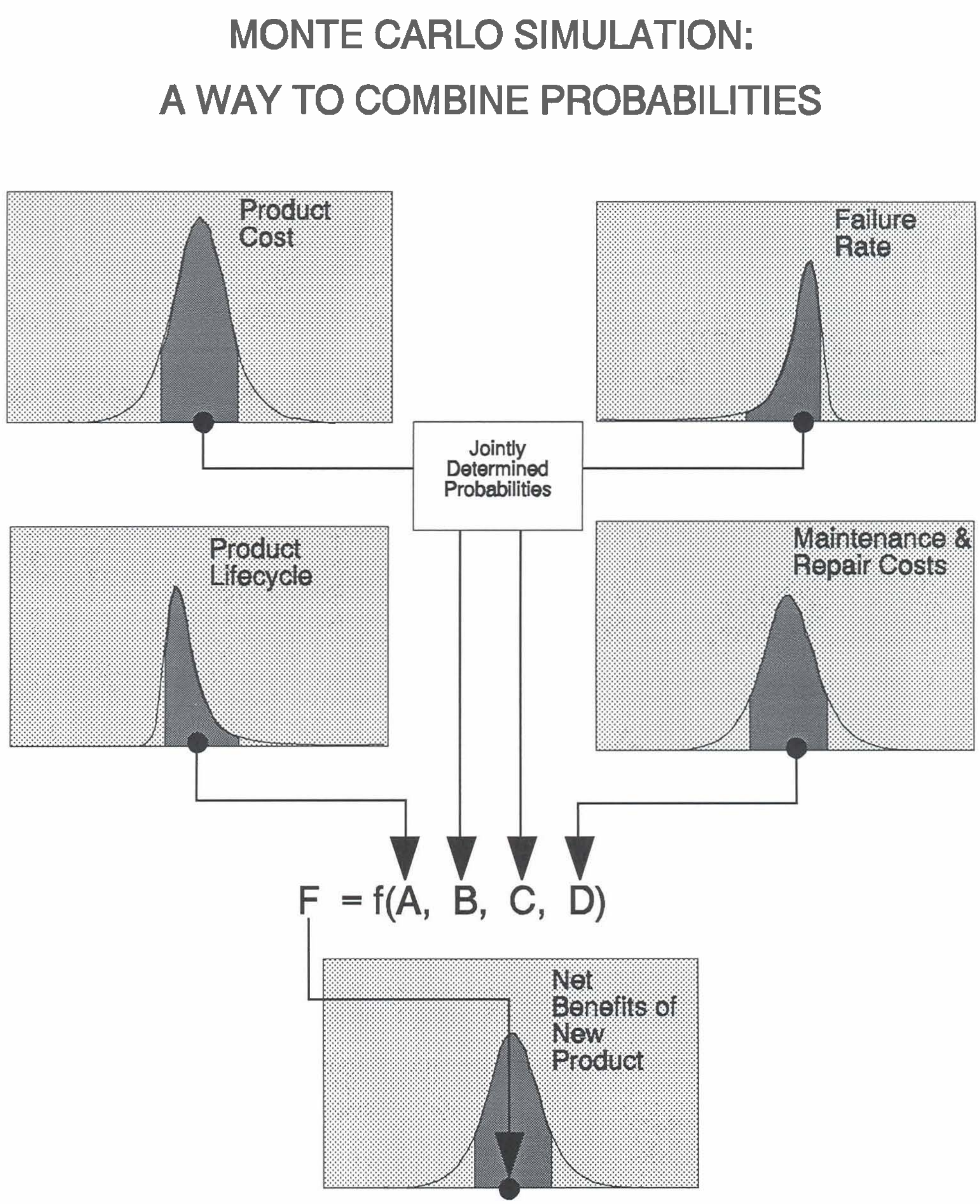
Figure 2.3: RAP Generated Probability Distribution



stakeholders and decision-makers to understand and participate in the process whether or not they possess statistical training.

Once the probability distributions for all changes in common and specific product attribute variables are entered into PEM, the risk analysis software produces probability distributions for each metric. Values for each variable are based on these distributions and are incorporated into the model to yield a final result. (see Figure 2.4). The result of this process represents both a forecast of the net economic benefits and quantification of the probability that the forecast will be achieved.

Figure 2.4: Monte Carlo Simulation: A Way to Combine Probabilities

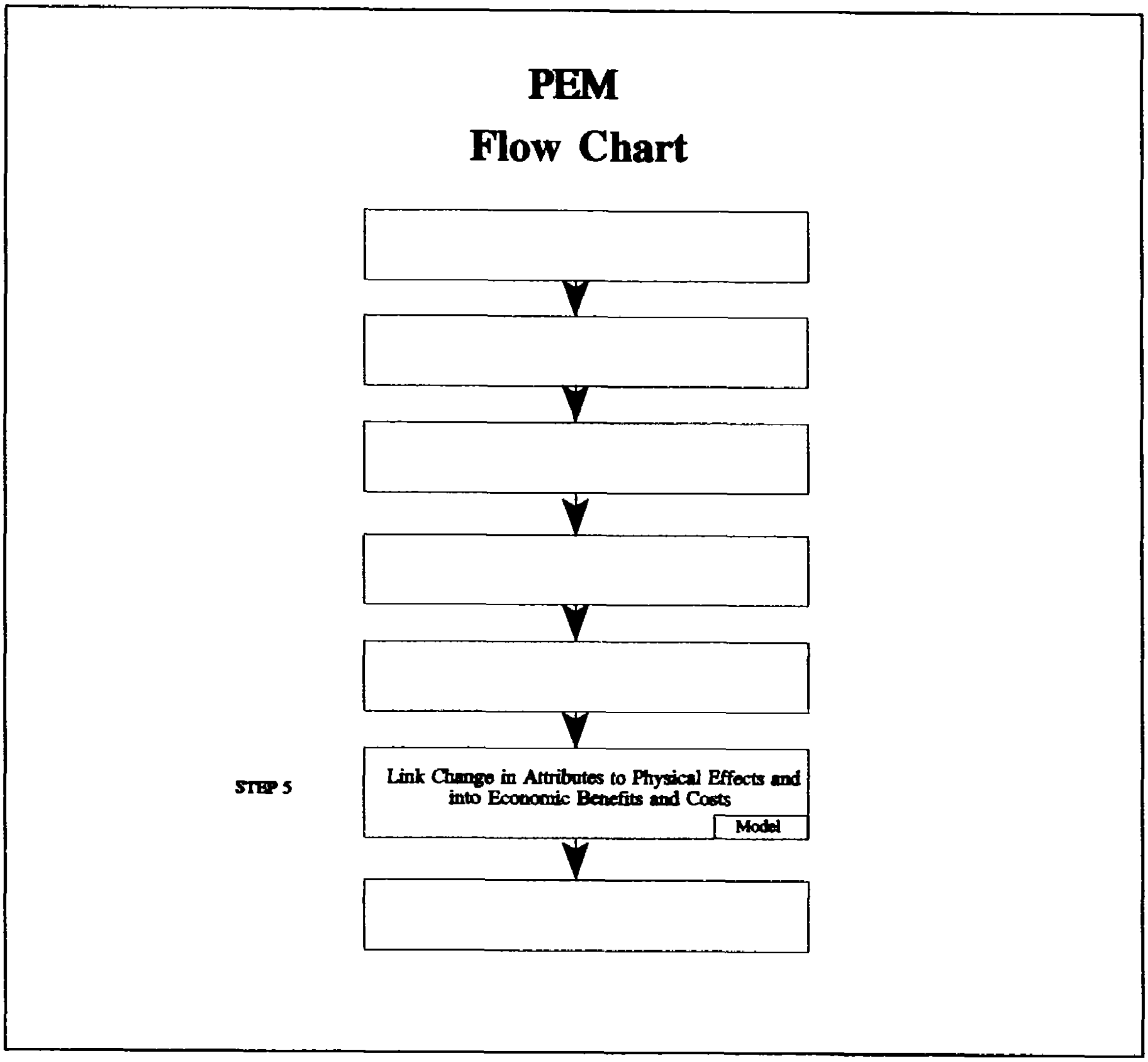


The Expanded RAP, Variation Two

Variation two of PEM's RAP component follows the same steps as variation one, but is geared towards a **panel discussion** of the probability ranges around common and specific product attributes. The RAP panel session, facilitated by the ATRC, is conducted as a structured workshop to further evaluate the costs and benefits associated with a given product. ADOT personnel, company representatives and industry experts are invited to the RAP session to evaluate the forecasting assumptions and the estimated probabilities associated with product data. PEM can be used for real-time modelling during the RAP session to test alternative product performance scenarios which incorporates the judgement of panel members and builds confidence in the forecasts.

Expanded RAP sessions can be held on an ad hoc or regular basis depending on the desires of the ATRC. Participants in a RAP session should receive a briefing book in advance containing information on the product and suggested probability ranges around common and specific product attribute variables. During the session, panelists review PEM (via the Structure-and-Logic Models, graphical diagrams of the relationships between model variables, which are located at the end of Section 2.7) and review and comment upon each Data Sheet containing the product information. This approach facilitates consensus building in the underlying forecasting assumptions and associated probabilities concerning product performance.

PEM STEP 5



In PEM step 5, the model calculates the economic benefits of new highway and construction products based on the inputs of earlier stages of the PEM process and the large body of transportation research data. To determine the economic benefits and costs associated with a specific new product, the analyst follows the steps 1-4 of the PEM process, which solicit median and probability ranges for the main product variables used in the cost-benefit analysis. PEM then maps the values for the Base Case and New Product variables into the economic effect categories defined in transportation and economics literature.

PEM explicitly considers eight categories of economic effect areas, and indirectly considers two further categories based on a threshold analysis. Each explicit category has an individual Structure & Logic diagram which charts the interaction between quantitative inputs for roadway characteristics, highway user cost data and common and specific product attributes and their resulting net benefit outputs. PEM accounts for following economic effects:

Explicit Economic Effect Categories

- Safety;
- Value of Time;
- Vehicle Operating Costs;
- Disruption Costs;
- Productivity Costs;
- Capital Expenditures;
- Maintenance Costs; and
- Liability Costs;

Indirect Economic Effect Categories

- Environmental Costs; and
- Aesthetic Costs.

The following sections present an explanation of the economic effect categories in PEM and are meant to accompany the Structure and Logic Diagrams. A detailed description of each input variable in the Structure and Logic Diagrams is presented in the User's Manual.

Safety

PEM considers safety-related costs as the statistical value of human life as well the value of non-fatal accidents and property damage. Accident rates are calculated separately for three events: "property damage-only" accidents, injuries (as opposed to injury-producing accidents) and fatalities. The specific values for these three types of events are taken from The Cost of Highway Crashes[7] prepared for the Federal Highway Administration by the Urban Institute. The methodology and calculation of the accident incident rate for each event is explained in further detail in the User's Guide.

A fundamental safety-related issue revolves around the valuation of life and injuries. Measuring safety benefits (or accident costs) per incident involves correctly identifying (1)

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[7] The Urban Institute, The Costs of Highway Crashes (Washington D.C.: The Urban Institute, 1991). (prepared under FHWA contract DTFH61-85-C-00107).

losses involved and (2) the value of the benefit to the population stemming from the change in its exposure to physical risk. The first part, identifying losses is a fairly direct process involving compilation and analysis of existing data. The second, however, involves the indirect measurement of what people will pay for safety benefits. A near consensus exists on the methodology to be employed in measuring safety benefits using the willingness to pay approach, but the "value of life" approach is also gaining acceptance. Since the willingness to pay for risk reduction may vary for individuals both with respect to income and risk profile, a framework for evaluating safety benefits is needed, so that the "value of life" and measures of risk exposure can be identified or refined.

In a benefit-cost analysis of a highway improvement, reliable predictions of accident frequency and severity are as significant in determining total accident costs as is the estimation of the unit costs of accidents, broken down by degree of severity.

Value of Time

PEM considers the value of time as an important economic effect category related to the use of a product. Highway investment proposals, for instance, typically derive most of their appraised benefits from estimated savings in costs associated with travel time delays. A new product which produces a similar reduction in delays, through increased productivity or a shorter application time, for example, may also lead to savings in the value of time. How to place a value on the time lost through highway delays has long been a significant issue in the estimation of highway user costs.

The value of delay and time savings has long been known to be a significant element of highway user cost. Current thinking and state-of-the-art studies hold that the value of travel time represents the marginal rate of substitution of money for travel time, i.e., travel time values are based upon estimates of the amount of money decision-makers are willing to pay for a reduction in the amount of time that they, or a shipped commodity, spend in travel.

PEM uses speed/flow formulae to first determine the average vehicle speed for given facility types and traffic volumes. These formulae are consistent with the view of traffic speed/flow presented in the AASHTO Redbook (1977)[8]. The specific data used to derive the coefficients for these formulae comes from HERS[9], and from the Texas Transportation Institute[10]. The monetary values applied to time savings in PEM are

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[8] American Association of State Highway and Transportation Officials. A Manual on User Benefit Analysis of Highway and Bus-Transit Improvements 1977. (Washington D.C.: 1978)

[9] Ibid, The Highway Economic Requirements System.

[10] Ibid, Technical Memorandum for NCHRP 7-12.

derived from information supplied from the Maricopa Association of Governments, Transportation and Planning Office which combines the percentage of person-trips by purpose obtained from household travel surveys with the average wage rate per sector and the occupancy rate per purpose to determine an average value of time for person/trips.

Vehicle Operating Costs

PEM considers vehicle operating costs as the cost of fuel, oil, maintenance and repairs, tire wear and highway-related vehicle depreciation. Generally speaking, vehicle operating costs are calculated based on posited mechanistic relationships between consumption rates for vehicle operating cost components on one hand, and highway conditions and traffic characteristics on the other. Information on these costs, as well as the methodology used to obtain them, can be found in HERS[11] and the Technical Memorandum to NCHRP 7-12[12].

In existing economic evaluation models for estimating highway operating costs, the prices associated with the consumption of key components are used only to convert quantity-based consumption rates developed in the models to an economic metric. Those models do not reflect the impact of price changes on changes in the levels of consumption of a particular cost component or cluster of components. Nor do they reflect the influence of other economic factors like changes in income levels.

Disruption Effects

In PEM, disruption effects are linked to the amount of time and the potential impact the disruption has on traffic during product installation or maintenance. The net disruption cost savings measures the incremental effects of disruption, or the additional costs or savings to highway users associated with the installation or maintenance of a new product.

The variables affecting the net disruption costs affect three economic effect areas under PEM: Safety, Value of Time and Vehicle Operating Costs. A Base Case product that currently requires a 30 minute installation time, for example, impacts these three areas through the disruption's direct effect on each category. For Safety, the percentage of AADT affected by the disruption as well as the maximum effect of the disruption on accident rates are used to forecast the Safety Disruption Costs. The Value of Time and Vehicle Operating Costs, derived from the Technical Memorandum to NCHRP 7-12[13], are dependent upon on the percentage of AADT affected by the disruption and the length the disruption time. The sum of these three effect categories provides Base Case net

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[11] Ibid, The Highway Economic Requirements System.

[12] Ibid, Technical Memorandum for NCHRP 7-12.

[13] Ibid, Technical Memorandum to NCHRP Report 7-12.

disruption costs. A new product which reduces the disruption time, and/or the amount of traffic affected by disruption and the disruption's maximum effect on accident rates, leads to a net savings in disruption costs and an economic benefit to the driver.

Productivity Effects

ADOT productivity effects refer to the overall reduced costs associated with a new product. A new, durable pavement that leads to a reduction in annual maintenance costs may contribute to ADOT productivity only if this new product does not increase other cost categories, such as associated capital expenses on new equipment. The important aspect of this benefit category is accounting for all administrative, as well as fabrication and maintenance and operating costs associated with existing products. PEM accounts for productivity effects in three areas of potential improvements, namely: administrative, fabrication, and maintenance and operating costs.

The basic methodology used to obtain productivity data for all areas considered by PEM is the same. It involves observing the number of units of a new product installed or applied in one hour divided by the number of workers. The resulting figure is the number of units per person per hour or the productivity associated with a given product. Productivity estimates for Administrative and Fabrication are obtained from ADOT groups directly affected by the use of the product. The PECOS II data system calculates productivity for all ADOT maintenance activities and many vendors provide similar calculations for their products. Graphical representations of the three elements of productivity: product units, time, and workers, and the process used to place a value on productivity improvements are presented in the "Net Productivity Savings," "Product Demand," "Net Maintenance and Operating Costs," and "Net Fabrication Costs" Structure and Logic Diagram presented at the end of this section.

Annual Capital Expenditures

PEM's Annual Capital Expenditures category is dependent on both ADOT management purchasing and inventory decisions as well as common product attributes and product performance. The interaction of these factors produces the Base Case and New Products which is incorporated into the Annual Capital Expenditures category.

The Product Demand model solicits information on current and projected inventory, phase-in/phase-out periods, and product performance in terms of useful and maximum useful economic life. These values are used to derive estimates of the Base Case purchasing and inventory patterns for the current product, as well as to calculate the costs associated with phasing-in a new product while simultaneously phasing-out the current product. The product demand sub-model results in outputs for annual Base Case and phase-in/phase-out product purchases which are used in the drive the forecasts in the Annual Captial Expenditures.

PEM's Annual Capital Expenditures economic effect category uses specific cost data for Base Case and New Products combined with previously derived product demand functions to forecast the annual capital expenditures associated with a specific product. Inventory and Carrying Costs, as well as Salvage and Disposal Costs are added to the model, depending upon the number of units held in inventory and the annual product failures, respectively. Like the Product Demand model, this model forecasts the Annual Capital Expenditures associated with the Base Case product and compares this figure to the combined Annual Capital Expenditures associated with the phasing-in of a new product and the phase-out of the current product.

Maintenance Costs

PEM's Maintenance Costs effect category considers a host of variables that are typically linked to the maintenance and upkeep of an installed product. The common product attributes which comprise maintenance costs include: hourly equipment costs, labor productivity, fabrication productivity, average ADOT labor wage, as well as the annual number of product replacements which is based on failure rate and the knock-down/vandalism rate. Specific product attributes which affect pavement condition are also considered in this category, since these products may affect ADOT's pavement maintenance costs. The sum of these two types of maintenance activities is an estimate of the annual Maintenance Costs associated with a specific product. A new product which reduces the costs in either maintenance activity, such as through reduced equipment costs, for example leads to overall maintenance cost savings and economic benefit associated with the product.

Liability Costs

Product liability and the cost of litigation associated with product failures represents an important economic benefit category to State DOTs. A new highway product that reliably and consistently provides the same or superior user benefits compared to current technology may decrease the claims against the state and, ultimately, liability costs. Although the probability of related accidents due to a specific product attribute may be very small, the model addresses their statistical occurrence based on the number of claims per 100 product failures, and considers the costs incurred for those cases that are settled and those cases that go to trial. This basic accounting of liability costs provides a monetary measure of the potential liability risks associated with the use of a new product. In instances where little or no reliable data is available for this benefit category, the user should contact ADOT Risk Management for an opinion on the product's potential liability costs, if any.

Environmental and Aesthetic Costs

PEM addresses the environmental and aesthetic costs associated with a product via a threshold analysis which indirectly places a monetary value on environmental and aesthetic benefits. This approach was adopted since modelling the environmental and aesthetic costs associated with each product depends upon a myriad of independent factors that cannot be easily generalized and incorporated into a model with the scope of PEM.

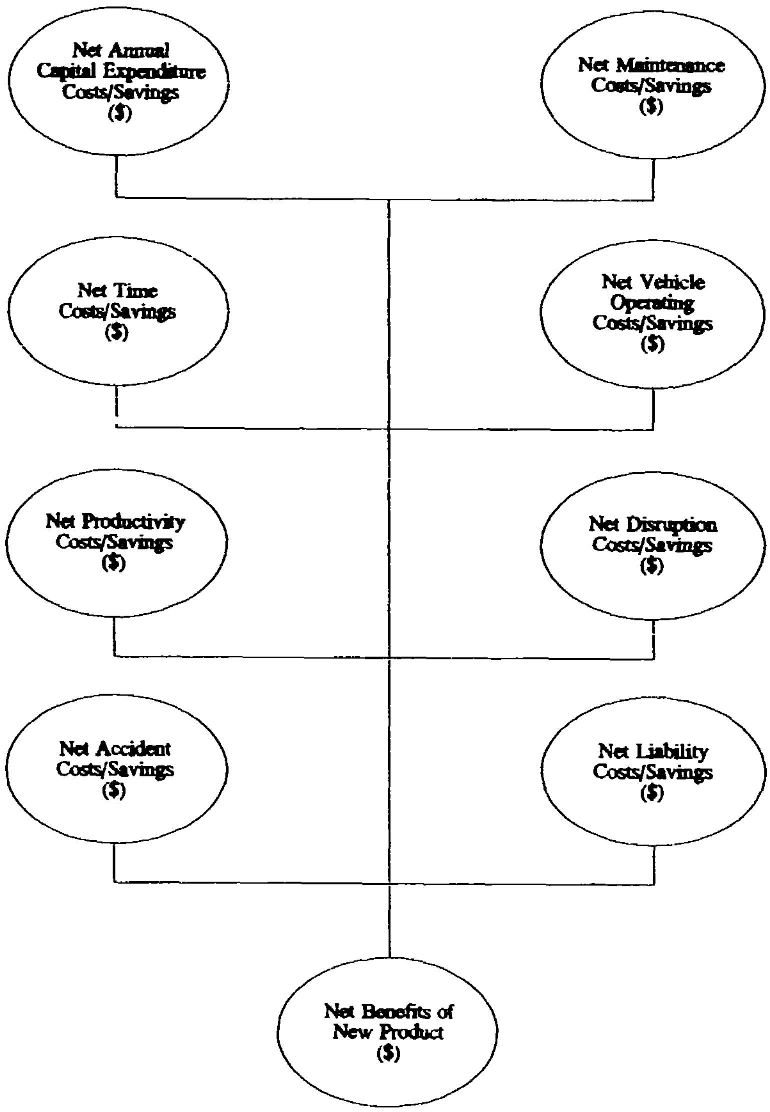
PEM's environmental and aesthetic costs threshold is based on 80 percent of the net economic benefits associated with a given product. A new product which produces a net economic cost, or negative benefit can potentially overcome this evaluation if it is determined that the environmental and aesthetic benefits associated with the product are at least equal to or exceed 80 percent of the net economic costs.

PEM's approach to environmental and aesthetic costs is ideally suited for variation two of the RAP component, although it can also be performed in variation one. As explained in PEM step 5, variation two is the expanded version of RAP in which ADOT personnel, company representatives and industry experts are invited to deliberate the probability ranges around central variables and to interpret PEM's forecasts. PEM's indirect estimation of environmental and aesthetic benefits provides the panel a starting point for discussing and forming a consensus about the value of these effects and their relationship to the product under consideration. Of course, PEM's threshold analysis of environmental and aesthetic costs associated with a product can also be evaluated by a single analyst, although this approach may limit the range of opinion concerning the value of these benefits.

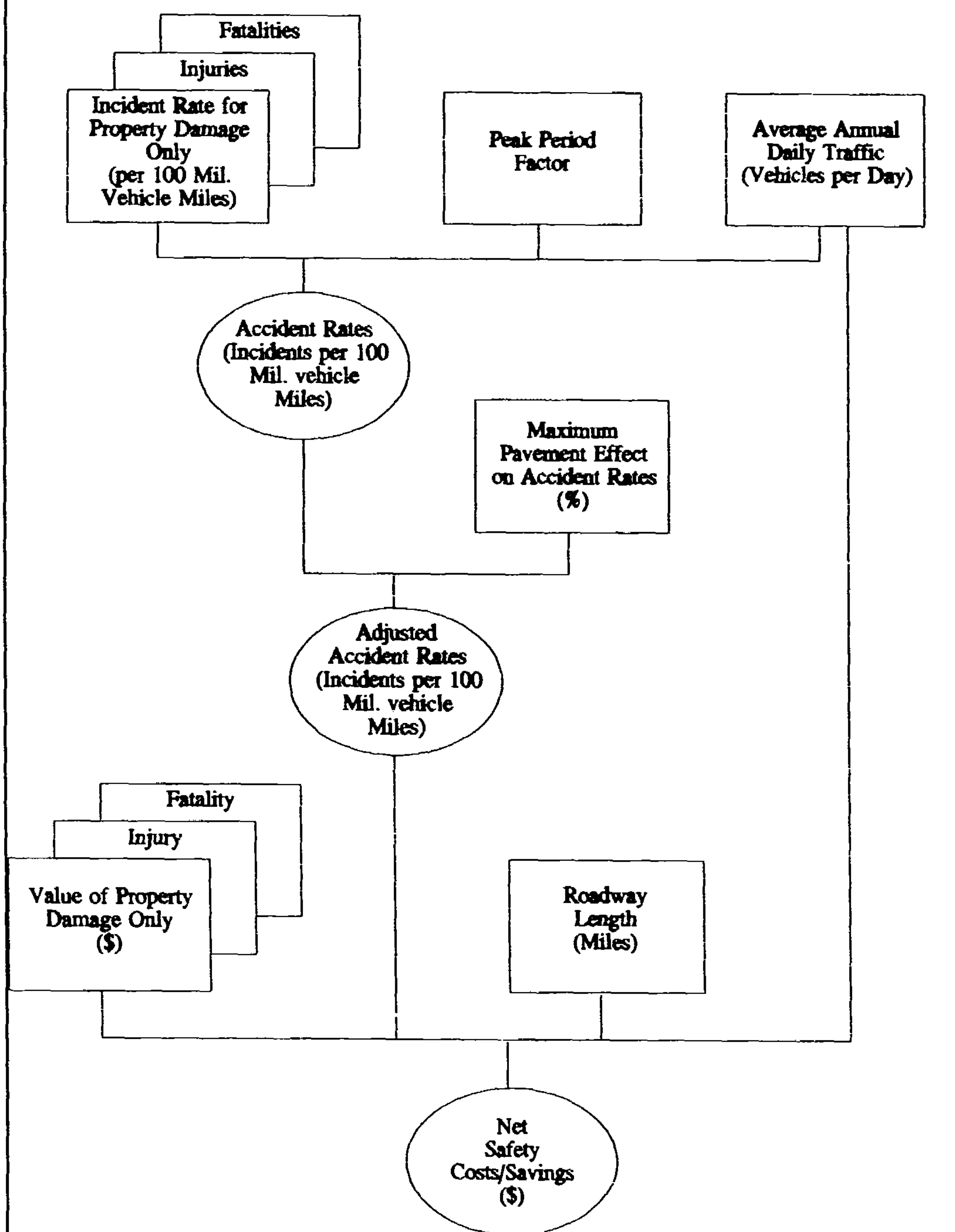
Structure and Logic Diagrams

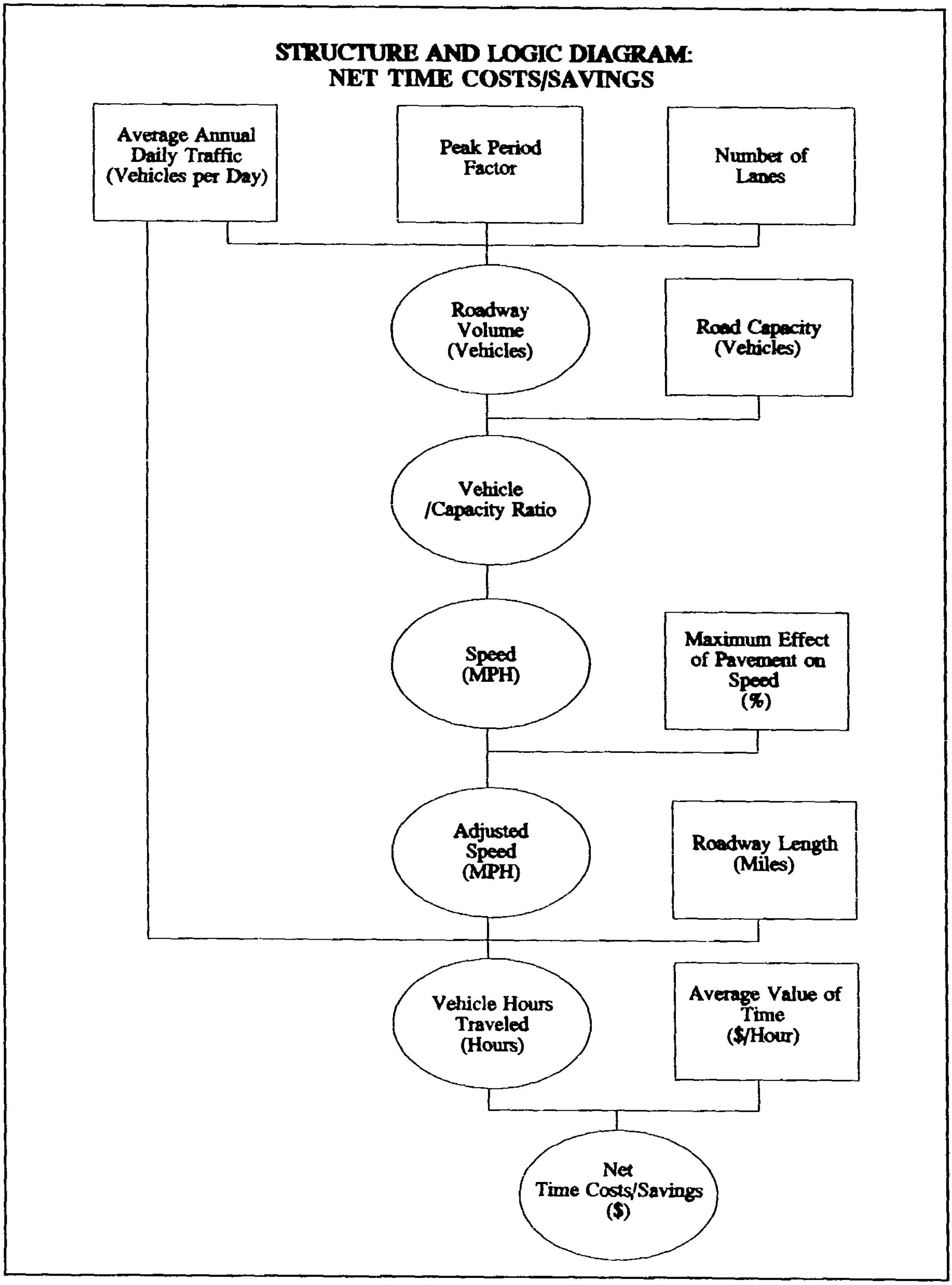
The following pages present the Structure and Logic Diagrams for each of the economic effect categories explained above. In each diagram, squares represent inputs to the model, while ovals represent outputs or outcomes from the relationships in the model. By using these diagrams, the user will be able to trace the path from the model inputs to the economic benefit categories.

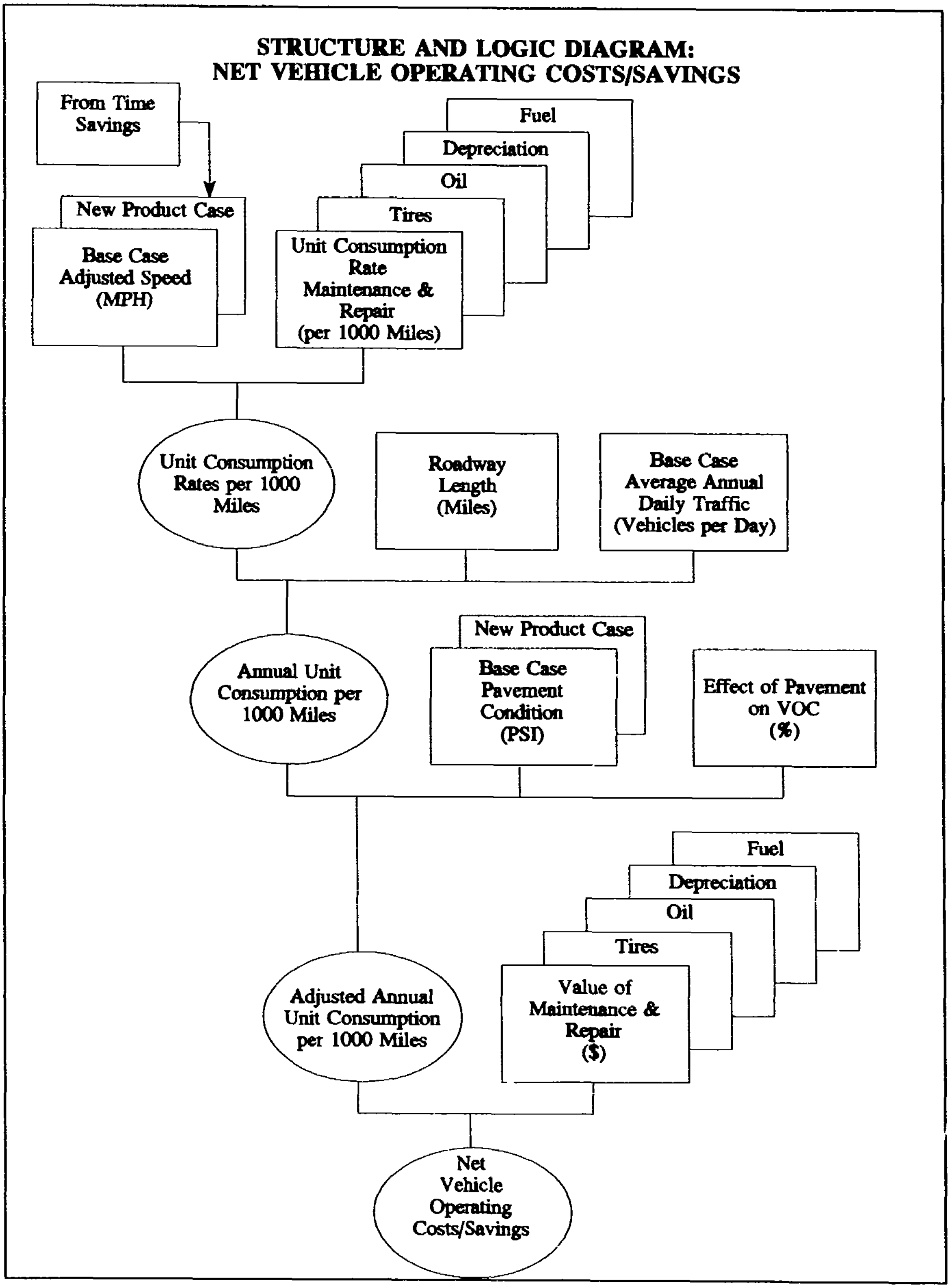
STRUCTURE AND LOGIC DIAGRAM: OVERVIEW OF THE BENEFIT- COST ANALYSIS



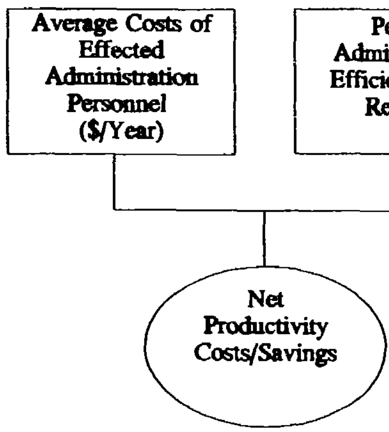
**STRUCTURE AND LOGIC DIAGRAM:
NET SAFETY COSTS/SAVINGS**

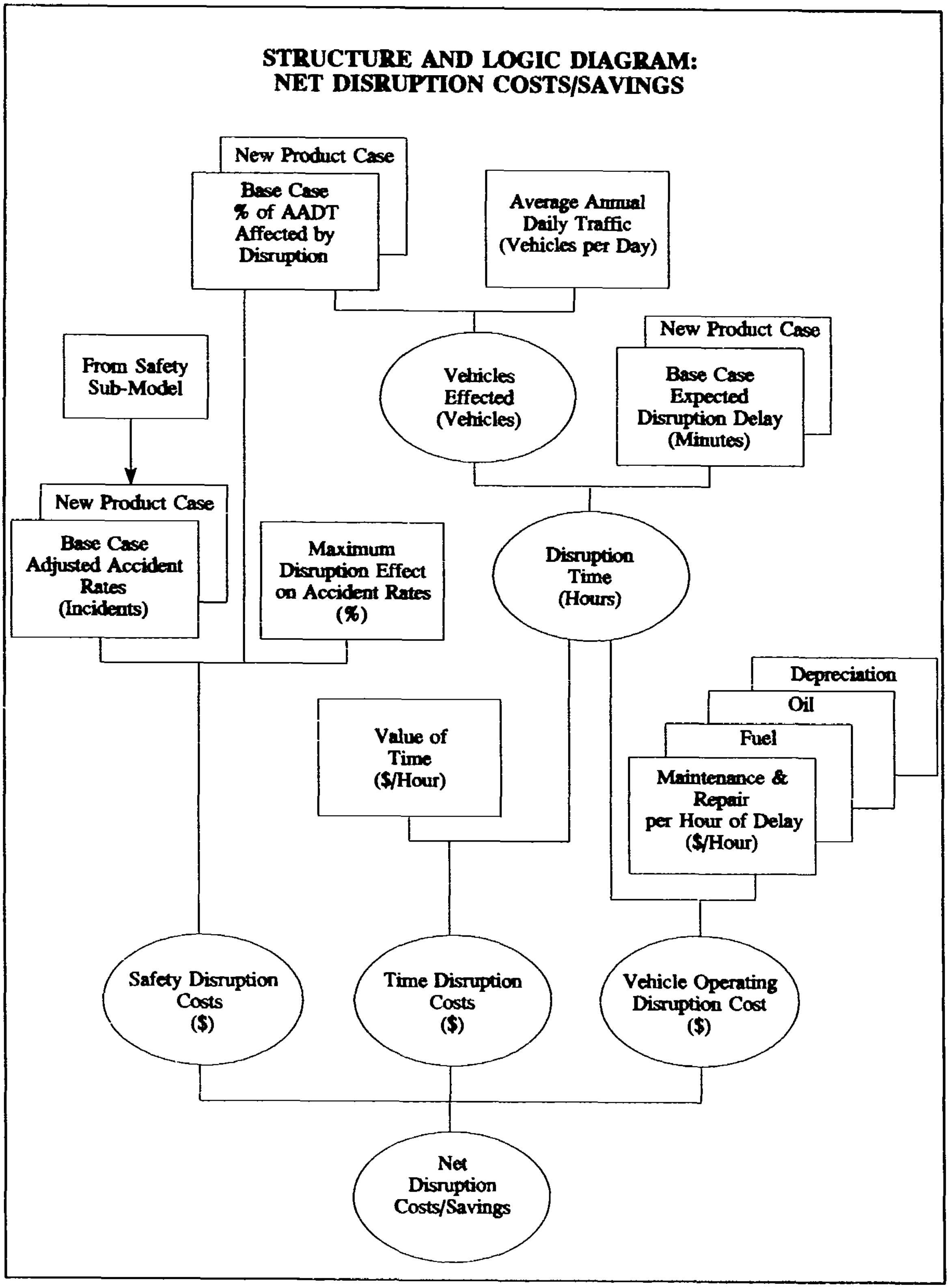



STRUCTURE AND LOGIC DIAGRAM:
NET TIME COSTS/SAVINGS
Average Annual Daily Traffic (Vehicles per Day)
Peak Period Factor
Number of Lanes
Roadway Volume (Vehicles)
Road Capacity (Vehicles)
Vehicle /Capacity Ratio
Speed (MPH)
Maximum Effect of Pavement on Speed (%)
Adjusted Speed (MPH)
Roadway Length (Miles)
Vehicle Hours Traveled (Hours)
Average Value of Time ($/Hour)
Net Time Costs/Savings ($)

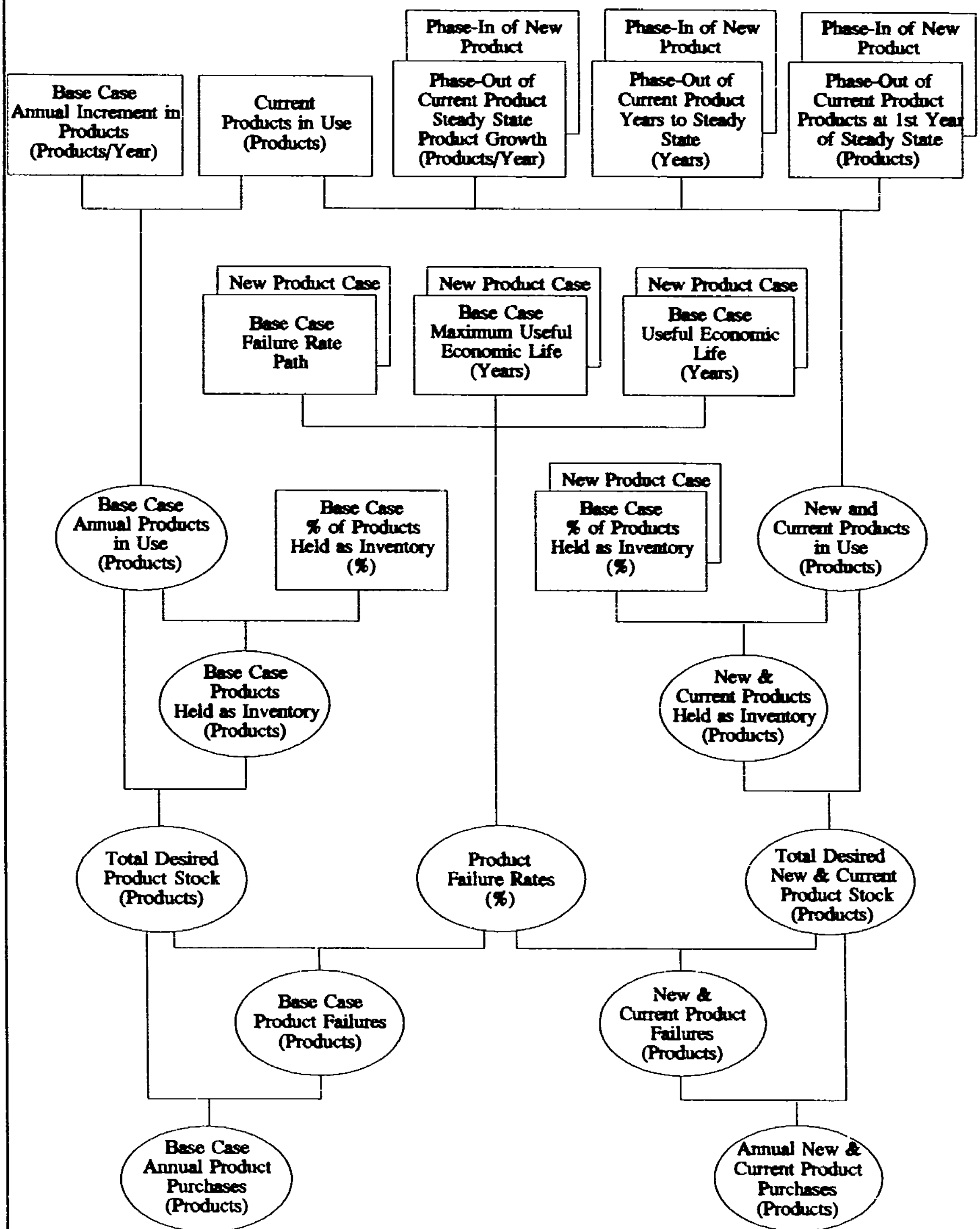

STRUCTURE AND LOGIC DIAGRAM:
NET VEHICLE OPERATING COSTS/SAVINGS
From Time Savings
New Product Case
Base Case Adjusted Speed (MPH)
Fuel
Depreciation
Oil
Tires
Unit Consumption Rate Maintenance & Repair (per 1000 Miles)
Unit Consumption Rates per 1000 Miles
Roadway Length (Miles)
Base Case Average Annual Daily Traffic (Vehicles per Day)
Annual Unit Consumption per 1000 Miles
New Product Case
Base Case Pavement Condition (PSI)
Effect of Pavement on VOC (%)
Fuel
Depreciation
Oil
Tires
Value of Maintenance & Repair ($)
Adjusted Annual Unit Consumption per 1000 Miles
Net Vehicle Operating Costs/Savings

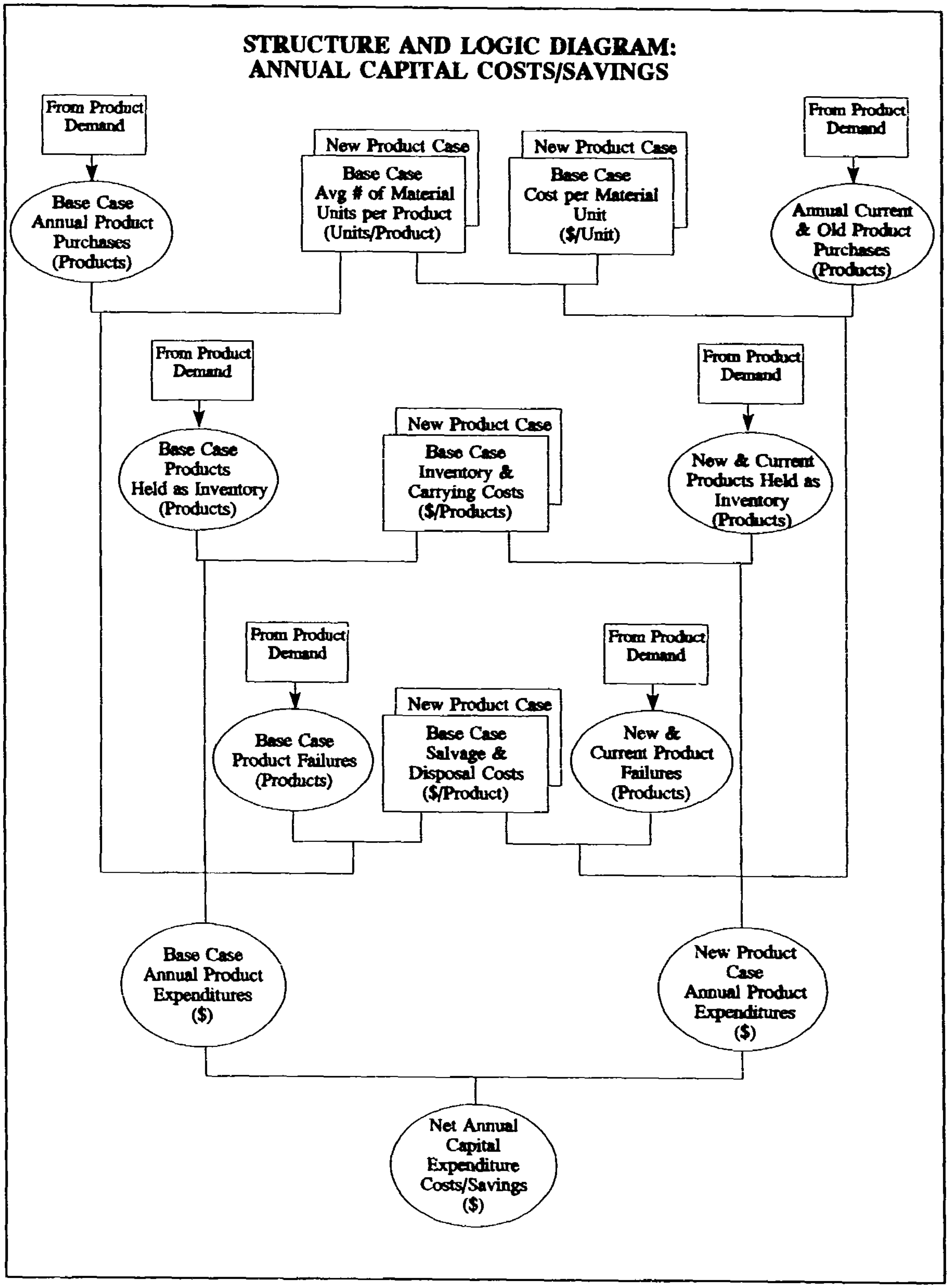
STRUCTURE AND LOGIC DIAGRAM:
NET PRODUCTIVITY COSTS/SAVINGS

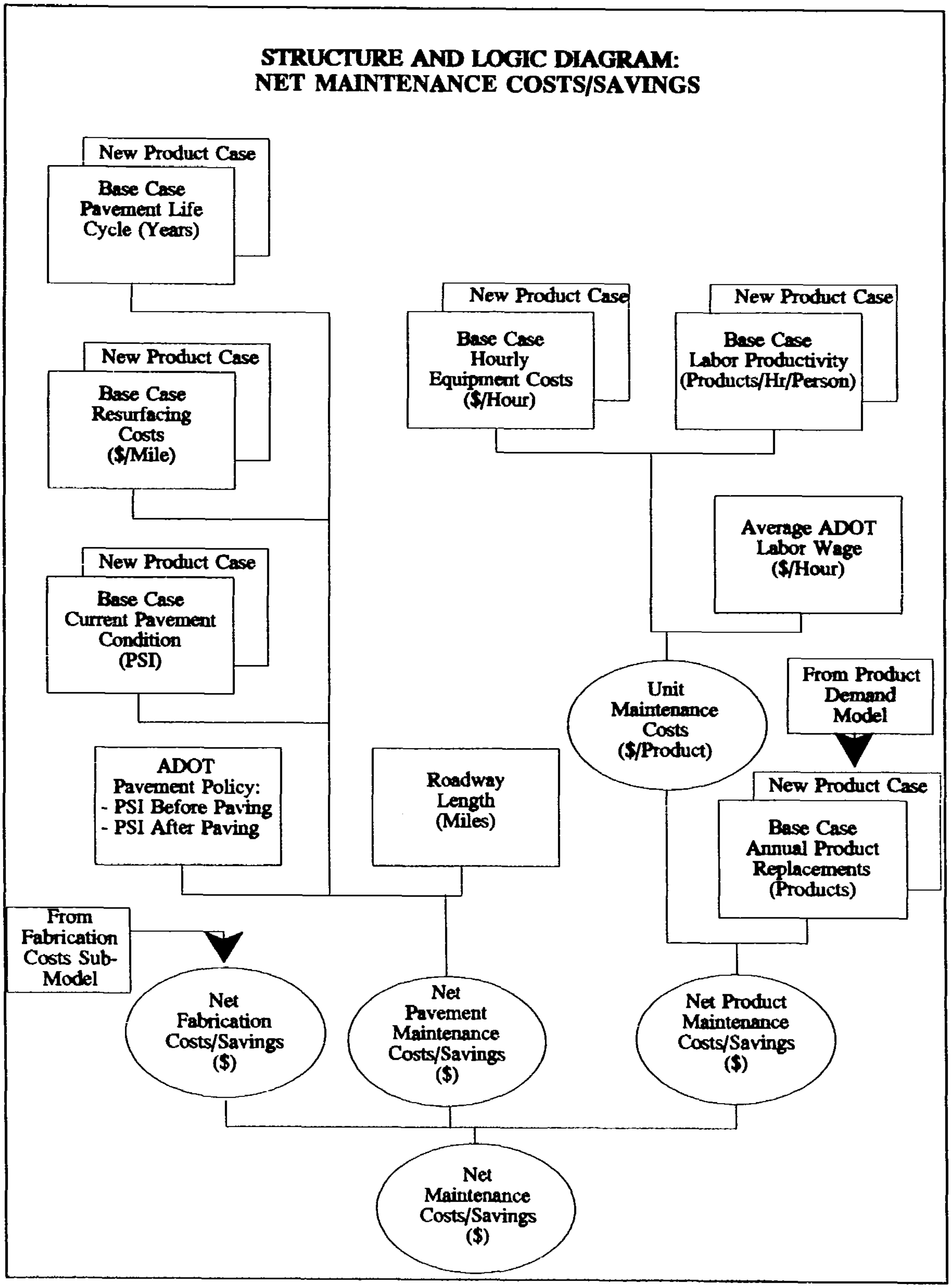


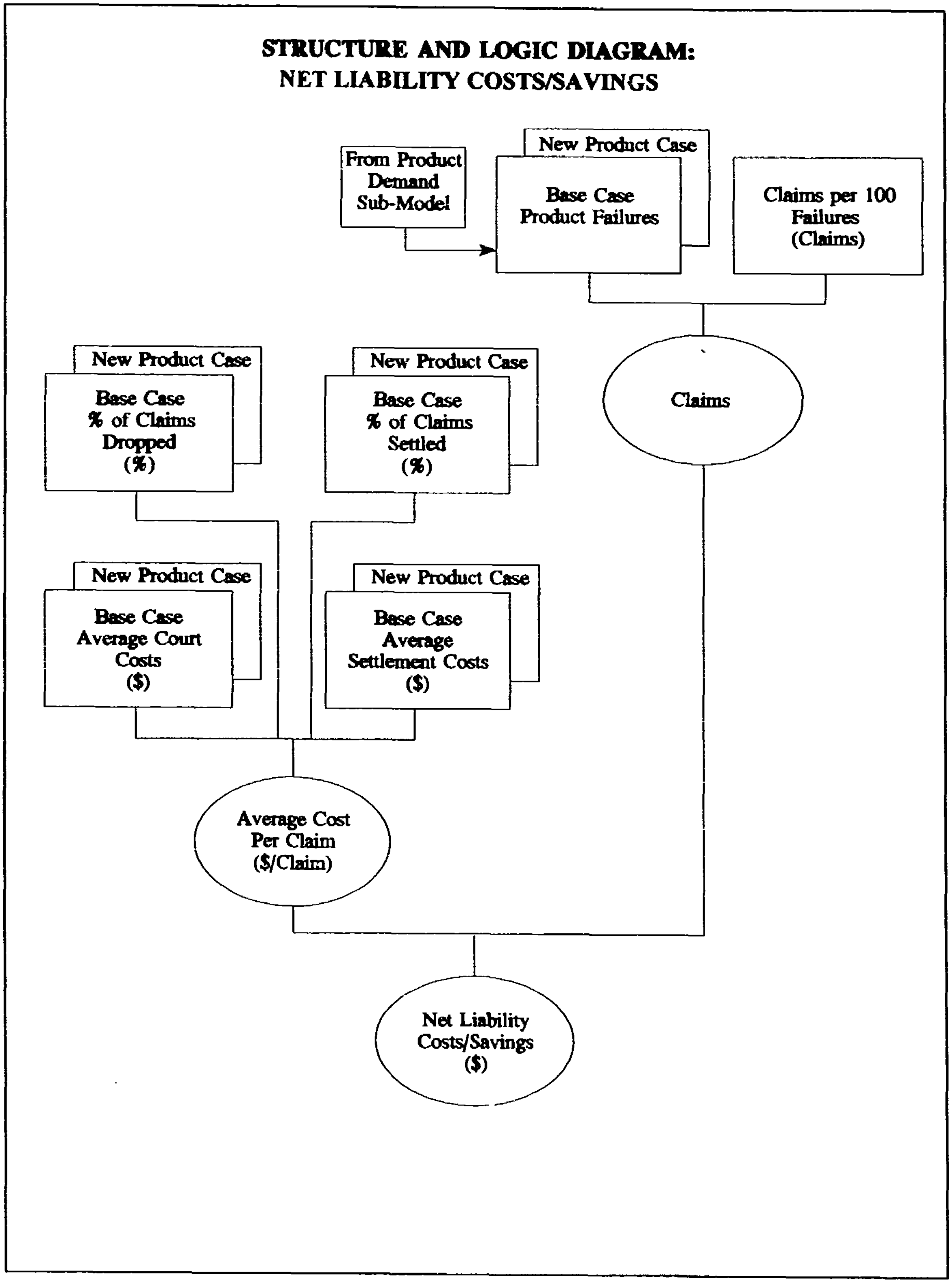

STRUCTURE AND LOGIC DIAGRAM:
NET DISRUPTION COSTS/SAVINGS
New Product Case
Base Case % of AADT Affected by Disruption
Average Annual Daily Traffic (Vehicles per Day)
From Safety Sub-Model
Vehicles Effected (Vehicles)
New Product Case
Base Case Expected Disruption Delay (Minutes)
New Product Case
Base Case Adjusted Accident Rates (Incidents)
Maximum Disruption Effect on Accident Rates (%)
Disruption Time (Hours)
Depreciation
Oil
Fuel
Maintenance & Repair per Hour of Delay ($/Hour)
Value of Time ($/Hour)
Safety Disruption Costs ($)
Time Disruption Costs ($)
Vehicle Operating Disruption Cost ($)
Net Disruption Costs/Savings

STRUCTURE AND LOGIC DIAGRAM: PRODUCT DEMAND IN BASE CASE AND NEW PRODUCT CASE




STRUCTURE AND LOGIC DIAGRAM: ANNUAL CAPITAL COSTS/SAVINGS
From Product Demand
Base Case Annual Product Purchases (Products)
New Product Case
Base Case Avg # of Material Units per Product (Units/Product)
New Product Case
Base Case Cost per Material Unit ($/Unit)
From Product Demand
Annual Current & Old Product Purchases (Products)
From Product Demand
Base Case Products Held as Inventory (Products)
New Product Case
Base Case Inventory & Carrying Costs ($/Products)
From Product Demand
New & Current Products Held as Inventory (Products)
From Product Demand
Base Case Product Failures (Products)
New Product Case
Base Case Salvage & Disposal Costs ($/Product)
From Product Demand
New & Current Product Failures (Products)
Base Case Annual Product Expenditures ($)
New Product Case Annual Product Expenditures ($)
Net Annual Capital Expenditure Costs/Savings ($)


STRUCTURE AND LOGIC DIAGRAM:
NET MAINTENANCE COSTS/SAVINGS
New Product Case
Base Case Pavement Life Cycle (Years)
New Product Case
Base Case Resurfacing Costs ($/Mile)
New Product Case
Base Case Current Pavement Condition (PSI)
ADOT Pavement Policy: - PSI Before Paving - PSI After Paving
Roadway Length (Miles)
New Product Case
Base Case Hourly Equipment Costs ($/Hour)
New Product Case
Base Case Labor Productivity (Products/Hr/Person)
Average ADOT Labor Wage ($/Hour)
Unit Maintenance Costs ($/Product)
From Product Demand Model
New Product Case
Base Case Annual Product Replacements (Products)
From Fabrication Costs Sub-Model
Net Fabrication Costs/Savings ($)
Net Pavement Maintenance Costs/Savings ($)
Net Product Maintenance Costs/Savings ($)
Net Maintenance Costs/Savings ($)


STRUCTURE AND LOGIC DIAGRAM:
NET LIABILITY COSTS/SAVINGS
From Product Demand Sub-Model
New Product Case
Base Case Product Failures
Claims per 100 Failures (Claims)
Claims
New Product Case
Base Case % of Claims Dropped (%)
New Product Case
Base Case % of Claims Settled (%)
New Product Case
Base Case Average Court Costs ($)
New Product Case
Base Case Average Settlement Costs ($)
Average Cost Per Claim ($/Claim)
Net Liability Costs/Savings ($)

STRUCTURE AND LOGIC DIAGRAM: NET FABRICATION COSTS/SAVINGS